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Inorganic Arsenic Emissions from Glass Manufacturing Plants: Background Information for Promulgated Standards

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Research Triangle Park, NC

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Inorganic Arsenic Emissions from Glass Manufacturing Plants —

Background Information for Promulgated Standards

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Standards to control emissions of inorganic arsenic from glass manufacturing plants are being promulgated under the authority of Section 112 of the Clean Air Act. This standard applies to new and existing glass manufacturing plants.

This document contains a summary of public comments, EPA responses, and a discussion of differences between the proposed and promulgated standard.

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Inorganic Arsenic Emissions from Glass Manufacturing Plants —

Background Information for Promulgated Standards

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

May 1986

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ENVIRONMENTAL PROTECTION AGENCY

Background Information Final Environmental Impact Statement for Inorganic Arsenic Emissions from Glass Manufacturing Plants

Prepared by:

Jack R. Farmer 5/1/86

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Research Triangle Park, North Carolina 27711

1. The promulgated standards will limit emissions of inorganic arsenic from existing and new glass manufacturing plants. The promulgated standards implement Section 112 of the Clean Air Act and are based on the Administrator's determination of June 5, 1980 (48 FR 37886) that arsenic presents a significant risk to human health as a result of air emissions from one or more stationary source categories, and is therefore a hazardous air pollutant.

2. Copies of this document have been sent to the following Federal Departments: Office of Management and Budget; Labor, Health and Human Services, Defense, Transportation, Agriculture, Commerce, Interior, and Energy; the National Science Foundation; the Council on Environmental Quality; members of the State and Territorial Air Pollution Program Administrators; the Association of Local Air Pollution Control Officials; EPA Regional Administrators; and other interested parties.

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TABLE OF CONTENTS

Page

Chapter 1 - Summary 1-1

1.1 Summary of Changes Since Proposal 1-1
1.2 Summary of Impacts of Promulgated Action 1-3

Chapter 2 - Summary of Public Comments 2-1

2.1 Affected Facilities 2-1
2.2 Stringency of the Proposed Emission Limit 2-11
2.3 Selection of Control Technology 2-17
2.4 Cost Effectiveness of the Proposed Standard 2-22
2.5 Economic Impact 2-22
2.6 Exemptions and Allowances 2-25
2.7 Monitoring and Measurement Methods 2-29
2.8 Determination of Compliance 2-37
2.9 Reporting Requirements 2-41
2.10 Arsenic Emissions from Soda-Lime Furnaces 2-42
2.11 Zero Production Offsets 2-48
2.12 Risk Assessement and Risk Management 2-49

Appendix A - Summary of Results of Emission Testing Performed After Proposal A-1

Appendix B - Updated Cost and Economic Analysis B-1

Appendix C - Available Arsenic Emissions Data for Existing Arsenic-Using Glass Plants C-1

Appendix D - Inorganic Arsenic Risk Assessment for Glass Manufacturing Plants D-1

1.0 SUMMARY

On July 20, 1983, the Environmental Protection Agency (EPA) proposed standards for inorganic arsenic (48 FR 33112) pursuant to Section 112 of the Clean Air Act which requires national emission standards for hazardous air pollutants (NESHAP). The proposed standard covered the following categories of sources of inorganic arsenic: high-arsenic primary copper smelters, low-arsenic primary copper smelters, and glass manufacturing plants. EPA also identified six additional source categories, but determined that standards are not warranted at this time.

Public comments were requested on the proposal in the Federal Register. This document addresses the comments pertaining to glass manufacturing plants. After proposal, the public comment period for the proposed standards for glass manufacturing plants was reopened on March 20, 1984 (49 FR 10278). Additional comments were solicited for one month concerning inorganic arsenic emissions from soda-lime glass manufacturing and concerning zero production rate offsets.

There were 24 comment letters submitted concerning the standards for glass manufacturing. Eleven letters were from industry, seven from state agencies, four from environmental groups, one from the Office of Management and Budget, and one from two private individuals. In addition, two industry and one environmental group spokesman testified about the arsenic NESHAP for glass manufacturing plants at the public hearing.

The comments submitted, along with responses to these comments, are summarized in this document. The summary of comments and responses serves as the basis for the revisions made to the standard between proposal and promulgation.

1.1 SUMMARY OF CHANGES SINCE PROPOSAL

In response to public comments received on the proposed rulemaking and as a result of EPA re-evaluation, five major changes were made to the proposed standard. These changes involve (1) revising the cutoff for existing furnaces, (2) revising the format of the emission limits,

(3) allowing the control device to be by-passed for periods of maintenance, (4) eliminating the exemption to 40 CFR Part 60, Subpart CC for sources that comply with the NESHAP, and (5) establishing a provision to exempt certain sources from testing procedures.

Existing Furnace Cutoff

Further examination of risks associated with arsenic emissions from specific existing glass manufacturing plants led the Agency to change the regulation by establishing the cutoff on uncontrolled arsenic emissions for existing glass melting furnaces at 2.5 Mg (2.75 tons) per year. The proposed cutoff on uncontrolled arsenic emissions of 0.4 Mg (0.44 ton) per year is retained for new or modified furnaces.

Format of the Standard

The second major change in the regulation since proposal involves a change in the format of the emission limits. The promulgated standard requires owners or operators of existing glass furnaces to ensure either that uncontrolled total arsenic emissions are less than 2.5 Mg (2.75 tons) per year or that arsenic emissions are reduced by 85 percent.

By-pass of the Control Device

The third major change in the regulation allows glass furnace owners or operators to petition the Administrator for permission to by-pass the control device for a limited period for control device maintenance purposes. After receiving a comment requesting this provision, the Agency investigated the cost and environmental impacts associated with performing routine maintenance on emission control devices installed on affected glass furnaces. EPA concluded that control devices could be by-passed during maintenance because the cost of requiring a temporary shutdown during maintenance would be excessive without offsetting environmental benefits and because the use of well maintained control devices is essential in effectively controlling arsenic emissions on a continuing basis. However, the Agency has included provisions to requie plants to minimize arsenic emissions during maintenance periods and will allow it only upon demonstration of its necessity.

Elimination of Exemption from NSPS

In the proposed standard, particulate emission limits were identical to those in the glass manufacturing NSPS (40 CFR Part 60, Subpart CC) and no furnace was allowed to operate with uncontrolled arsenic emissions in excess of 0.4 Mg (0.44 ton) per year. The promulgated standard has been revised such that the emission limits are no longer identical and the exemption from the NSPS is no longer appropriate.

Compliance Testing

In the final major change, EPA created a provision to exempt certain sources from performing emission tests to demonstrate compliance. Existing sources that add less than 8.0 Mg arsenic per year to the batch and new or modified sources that add less than 1.0 Mg arsenic per year to the batch will be exempted from performing emission tests. Analysis has shown that if an existing or new source adds less arsenic than these amounts to the raw materials, it would emit less than 2.5 Mg (2.75 tons) or 0.4 Mg (0.44 ton), respectively. In these cases, the Administrator has concluded that emission testing is not necessary.

1.2 SUMMARY OF IMPACTS OF PROMULGATED ACTION

1.2.1 Alternatives to Promulgated Action

Regulatory alternatives considered during development of the standard are discussed in Chapter 4 of "Inorganic Arsenic Emissions from Glass Manufacturing Plants - Background Information for Proposed Standards", EPA-450/3-83-011a, April 1983. This document is also referred to as the Background Information Document (BID). These regulatory alternatives reflect the different levels of emission control. After proposal, the Agency revised the emission limits as discussed in Section 1.1. These revisions made it necessary to recalculate environmental, energy, and economic impacts because fewer furnaces are affected by the revised emission limits.

1.2.2 Environmental Impacts of Promulgated Action

Under the promulgated standard, eight existing glass melting furnaces are subject to the control requirement and are required to reduce emissions of arsenic by 85 percent. Six of these furnaces are presently equipped with controls and will not be required to install any additional controls as a result of this standard. The reduction in arsenic emissions currently achieved on these six furnaces totals 30.4 Mg (33.4 tons) per year. The remaining two furnaces are presently uncontrolled and are required to install control devices capable of reducing arsenic emissions by at least 85 percent. However, one of these furnaces is expected to change production to a non-arsenic containing glass type while the other will install a control device. The total reduction in arsenic emissions expected to be achieved from these two furnaces is 14.6 Mg (16.1 tons) per year.

Because only one furnace is anticipated to install controls as a result of this standard, the total water and solid waste impact associated with the standard are those arising from this furnace. Application of controls to this furnace will not result in any emissions to water. The solid waste collected in the control device would amount to about 20 Mg (22 tons) per year. However, because reuse of this waste would result in cost savings for raw materials and because of the high costs of disposing of this waste, it is anticipated that about 90 percent of the total waste will be recycled to the melting furnace. Therefore, the total solid waste impact of the final standard is estimated to amount to about 2 Mg (2.2 tons) per year.

The analysis of environmental impacts presented in Volume I of this document, as modified by the changes described above, is the final environmental impact statement for this action.

1.2.3 Energy and Economic Impacts of Promulgated Action

Revisions in the emission limits since proposal have resulted in changes in the energy and economic impacts presented in the BID for the proposed standard.

Because only one presently uncontrolled furnace is anticipated to install controls as a result of the promulgated standard, the total energy impact of the standard is that associated with controlling this furnace. It is estimated that the application of controls will increase energy use at the plant by about 185 MW-hr per year. This represents about 0.1 percent of the total energy use at the plant.

The revised economic impacts are summarized and compared to the impacts of the proposed standard in Appendix B of this BID. Although at proposal information was available on the financial characteristics of the affected glass companies, sufficient data were not available to estimate the cost impacts of controlling all arsenic-using glass furnaces operated by those companies. Detailed information gathered after proposal was used to reassess economic impacts of control options. The revised analysis in Appendix B indicates moderate profit declines for most potentially affected furnaces with severe profit declines for a few furnaces. However, no adverse economic impacts are estimated for the single plant anticipated to install controls as a result of this action. There was little impact on capital availability.

1.2.4 Other Considerations

1.2.4.1 Irreversible and Irretrievable Committment of Resources.

Other than the fuels required for power generation and the materials required for the construction of the control system, there is no apparent irreversible or irretrievable commitment of resources associated with this regulation.

1.2.4.2 Environmental and Energy Impacts of Delayed Standards.

Delay in implementing the standard would result in a delay in emission reduction of arsenic from affected furnaces and delay in realization of other estimated impacts.

1.2.4.3 Urban and Community Impacts.

Neither plant closures nor impacts on small business are forecasted. The issue of plant closure is discussed in more detail in Section 2.5.

2.0 SUMMARY OF PUBLIC COMMENTS

A total of 24 letters commenting on the proposed standard for the glass industry were received. In addition, three speakers commented on the proposed standard at the public hearing. The transcript from the public hearing, comments made at the public hearing, and the 24 letters have been recorded and placed in the docket. The list of commenters, their affiliation, and the docket number assigned to each comment by the Environmental Protection Agency (EPA) are shown in Table 2-1. The docket reference number is indicated in parentheses in each comment summary. All docket references are part of Docket Number A-83-08, Category IV. The comments have been summarized according to the following 11 categories:

2.1 Affected Facility
2.2 Stringency of the Proposed Emission Limit
2.3 Selection of Control Technology
2.4 Cost Effectiveness of the Proposed Standard
2.5 Economic Impact
2.6 Exemptions and Allowances
2.7 Monitoring and Measurement Methods
2.8 Determination of Compliance
2.9 Reporting Requirements
2.10 Arsenic Emissions from Soda-lime Furnaces
2.11 Zero Production Offsets
2.12 Risk Assessment and Risk Management

2.1 AFFECTED FACILITIES

2.1.1 Comment: Three commenters (F-1, D-5, D-10) addressed the issue of whether the presence of arsenic as an impurity in the raw materials used to manufacture glass should be considered in determining the applicability of the standard. Each of these commenters expressed concern that it would be burdensome and costly to require facilities which do not use arsenic as

TABLE 2-1. LIST OF COMMENTERS ON THE PROPOSED STANDARDS FOR ARSENIC EMISSIONS FROM GLASS MANUFACTURING PLANTS

Docket Number A-83-08, IV

Public Hearing

Commenter	Docket Reference
Dr. Robert A. Drake Vice President, Technical Glass Packaging Institute 6845 Elm St., Suite 209 McLean, Virginia 22101	F-1
Mr. H. Neal Troy Manager of Environmental Control Owens-Illinois, Incorporated One Seagate Toledo, Ohio 43666	F-2
Mr. David D. Doniger Senior Staff Attorney Natural Resources Defense Council, Inc. 1725 I St., N.W. Suite 600 Washington, D.C. 20006	F-3

Letters

Commenter	Docket Reference
Mr. Thomas J. Koralewski Senior Environmental Engineer Libbey-Owens-Ford Company 1701 East Broadway Toledo, Ohio 43605	D-1
Dr. George and Adriana Hess 4437 West Grandview Place Tacoma, Washington 96466	D-2
Mr. Ben A. Brodovicz, Chief Division of Technical Services and Monitoring Bureau of Air Quality Control Department of Environmental Resources Post Office Box 2063 Harrisburg, Pennsylvania 17120	D-3

TABLE 2-1 CONTINUED

Commenter	Docket Reference
Mr. John T. Barr Regulatory Response Air Products and Chemical, Inc. Box 538 Allentown, Pennsylvania 18105	D-4
Mr. F. P. Partee Principal Staff Engineer Stationary Source Environmental Control Office Ford Motor Company One Parklane Blvd. Dearborn, Michigan 48126	D-5
Mr. Paul F. Munn Chief Engineer Department of Public Utilities Environmental Services Agency 26 Main Street Toledo, Ohio 43605	D-6
Mr. Bill Stewart Executive Director Texas Air Control Board 6330 Hwy 290 East Austin, Texas 78723	D-7
Anita Fries A-95 Coordinator State Clearinghouse 30 East Broad Street Colombus, Ohio 43215	D-8
Mr. Michael Gregory Grand Canyon Chapter, Arizona Sierra Club Rt. 1, Box 25A McNeal, Arizona 85617	D-9
Mr. Lowell D. Turnbull Leva, Hayes, Symington & Martin 815 Connecticut Ave., N.W. Washington, D.C. 20006	D-10
Executive Office of the President Office of Management and Budget Washington, D.C. 20503	D-11

TABLE 2-1 CONTINUED

Commenter	Docket Reference
Mr. David F. Zoll Vice President and General Counsel Chemical Manufacturers Association 2501 M Street, N.W. Washington, D.C. 20037	D-12
Mr. John L. Cherill Energy and Environmental Control Corning Glass Works Corning, New York 14830	D-13
Mr. Richard A. Kamp Smelter Crisis Eduction Project Post Office Box 5 Naco, Arizona 85620	D-14
Mr. H. M. Howe Chief Siting Engineer Pacific Gas and Electric Company 77 Beale Street San Francisco, California 64160	D-15
Robert Abrams Attorney General of the State of New York	D-16
Mary Lyndon Assistant Attorney General of the State of New York Two World Trade Center New York, New York 10047	D-17
David D. Doniger Senior Staff Attorney Natural Resources Defense Council 1725 I Street, N.W. Suite 600 Washington, D.C. 20006	D-18
Mr. H. Neal Troy Manager of Environmental Control Owens-Illinois, Incorporated One Seagate Toledo, Ohio 43666	D-23
David D. Doniger Senior Staff Attorney Natural Resources Defense Council 1725 I Street, N.W. Suite 600 Washington, D.C. 20006	D-24

TABLE 2-1 CONTINUED

Commenter	Docket Reference
Mr. John L. Cherill Energy and Environmental Control Corning Glass Works Corning, N.Y. 14830	D-25
Steven G. Kuhrtz Director New Jersey Department of Environmental Protection Division of Environmental Quality Trenton, N.J. 08625	D-26
Mr. Herbert Engel Decor, Incorporated 60 Cedar Lane Englewood, N.J. 07631	D-27
Mr. John L. Cherill Energy and Environmental Control Corning Glass Works Corning, N.Y. 14830	D-28

Docket entries D-19, D-20, D-21, and D-22 are not included in this list because they did not include comments pertaining to the proposed standard.

a raw material to demonstrate that emissions arising from trace arsenic contamination of other raw materials would not result in exceedance of the proposed emissions cutoff. The commenters requested that EPA explicitly exclude from the promulgated regulation all furnaces that do not intentionally use arsenic as a raw material. One commenter (D-10) noted that the arsenic content of raw materials is not routinely specified by purchasers since arsenic is not known to impair glass quality. However, the commenter indicated that in a telephone survey of glass manufacturers and raw material suppliers, no evidence was found that arsenic exists in significant quantities as an impurity of raw material components. The only detectable quantity of arsenic was found in Green River soda-ash at concentrations ranging from 0.03 to 0.05 parts per million (ppm). These concentrations would result in maximum uncontrolled arsenic emissions of about 1.1 kg (2.5 pounds) per year from a typical 227 Mg/day (250 tons/day) glass container furnace. This commenter concluded that EPA should give no consideration to the arsenic content of raw materials since there is no reason to believe that the arsenic content of raw materials used for glass manufacture is any higher than it is in raw materials used in other process industries. Another commenter (D-5) pointed out that for the size of furnace typically used to produce flat glass (500 to 600 tons/day), trace amounts of arsenic in the raw materials on the order of 2 to 3 ppm by weight could result in uncontrolled arsenic emissions approaching the proposed emission cutoff of 0.4 Mg/year (0.44 ton/year). The commenter is aware of only one conventional raw material that contains arsenic as an impurity. That one exception, an additive used in small amounts in producing body-colored glass, would result in arsenic emissions of less than one pound per year.

2.1.1 Response: EPA has examined the problems posed by the presence of arsenic as an impurity in various raw materials used in the production of glass, and has concluded, based on available information, that this source of arsenic is not expected to affect significantly the emissions of arsenic from glass manufacturing furnaces. The specific comment which appears to indicate that the presence of arsenic impurities may result in emissions approaching 0.4 Mg (0.44 ton) per year was closely examined. It was determined that the calculations present an unrealistic situation in presuming that all of the raw materials entering the furnace contain 2 to 3 ppm arsenic by weight, and that all of the arsenic entering the furnace is emitted. Because it would be uncommon for all raw materials to contain arsenic at that level, and because most of the arsenic is known to be retained in the product, EPA has concluded that the emissions calculated in the example given in the comment are substantially overstated and not indicative of an actual condition that might occur.

EPA has also independently investigated the concentration of arsenic found in the bulk raw materials commonly used in the glass industry. (Docket reference IV-B-12). During an emissions test of an arsenic-using furnace, samples of the bulk raw materials were taken and analyzed for arsenic content. With the single exception of barium carbonate, the concentrations of arsenic in the raw materials from this plant were below the detection limits of the analytical method used. The measured concentration of arsenic in the barium carbonate sample was 2.32 ppm. However, barium carbonate is not widely used in large quantities within the glass industry. Even assuming that the concentration of arsenic in bulk raw materials is equal to the detection limit of the analytical methods used on the test samples, the maximum uncontrolled emissions of arsenic arising from raw material impurities would be about 0.19 Mg/year (0.21 ton/year) from a furnace producing 500 Mg/day (550 tons/day) of glass.

Based on all of the information available to the Agency, glass melting furnaces which do not use commercial arsenic as an ingredient of their batch composition would not emit enough arsenic to be affected by the promulgated cutoff of 0.4 Mg (0.44 ton) per year for new and modified furnaces and 2.5 Mg (2.75 tons) per year for existing furnaces. EPA agrees it would be unreasonable to require demonstration of this and, therefore, the applicability section of the regulation has been revised to exclude from the promulgated standard all furnaces which do not use commercial arsenic as a raw material. Commercial arsenic is any variety of arsenic or arsenic compounds which is produced by extracting arsenic from minerals.

2.1.2 Comment: Two commenters (D-13; F-2) stated that the proposed regulation should be applicable only to furnaces that are at present uncontrolled. One commenter (D-13) added that all existing glass melting furnaces equipped with fabric filters or electrostatic precipitators should be excluded from further regulation under this NESHAP. The commenter stated that although uncontrolled furnaces are relatively few in number, the largest reductions in arsenic emissions could be obtained from these furnaces.

2.1.2 Response: Under the promulgated cutoff on arsenic emissions for existing sources, six currently controlled furnaces would be affected by the emission limits. However, all six of the furnaces are at present achieving the required reduction in arsenic emissions and no additional controls are required on these furnaces. The Agency wants to ensure that existing control devices will be properly operated and maintained because the health risks associated with emissions above the cutoff could be significantly reduced at reasonable cost. Therefore, it would not be in keeping with Section 112 of the Clean Air Act to exempt existing furnaces and to fail to ensure that control systems on these furnaces remain effective in reducing emissions.

2.1.3 Comment: One commenter (D-26) stated that EPA has relied totally on cost and economic factors in establishing 0.4 Mg (0.44 ton) per year as the cut-off between affected and unaffected furnaces in the proposed standard, and that no analysis of the impact of this cutoff on exposure or risk has been presented. The commenter urged that the data on exposure and risk should be presented so that the impact of the cutoff can be fully evaluated.

Another commenter (F-2) stated that the proposed emission cutoff of 0.4 Mg (0.44 ton) arsenic per year is overly stringent given the insignificant environmental benefits that would be gained from controlling emissions at this level. According to the commenter's calculations, the emissions from one of the commenter's plants, which emits more than the proposed cutoff, would contribute only 0.17 micrograms/cubic meter to the ambient concentration over an 8 hour period. This is only 2 percent of the OSHA standard of 10 micrograms/cubic meter. The commenter also referred to the previous testimony of Dr. Lamm (November 8, 1983 public hearing transcript, Docket No. A-83-08-IV-F), that ambient concentrations of 300 micrograms/cubic meter over a lifetime would be necessary to cause significant health impacts. If the furnace were controlled to the proposed emission limit of 0.2 lb particulate/ton of glass produced, the corresponding reduction in the ambient concentration of arsenic would be 0.13 micrograms/cubic meter. The commenter concluded that such a reduction is not justified given the costs required to achieve it and that the proposed emission cutoff should be increased by a factor of two or three and apply only to uncontrolled furnaces.

2.1.3 Response: At the time of proposal, the Agency's standard setting approach involved first selecting a standard that was achievable through the application of best available technology (BAT). Determination of BAT was based on the capability of existing technologies to reduce emissions, as well as on the costs of emission controls and on the economic impact of applying the controls at specific facilities. The residual risks remaining after application of BAT to furnaces which would have been affected by the proposed cutoff (0.4 Mg/year of arsenic prior to control) were then considered to determine if a more stringent standard would be necessary to protect public health. However, Agency policy has since evolved to place greater emphasis on risk and risk reduction in determining which specific sources within a source category shall be subject to an emission limit under Section 112. Costs and economic impact are still considered in relation to the reductions in risk achievable through the use of selected control technologies.

Because of various site-specific factors, the degree of risk associated with emissions of inorganic arsenic from glass manufacturing plants does not, in all cases, directly correlate with the absolute magnitude of those emissions. Moreover, risks to the population in the vicinity of a plant must be assessed in terms of emissions of arsenic from the entire plant, rather than emissions from individual furnaces within the plant. Therefore, in establishing an emission cutoff, the emphasis has shifted from consideration of the magnitude of the emissions arising from individual furnaces and the costs of controlling those emissions, to consideration of the magnitude of the risks associated with specific plants and the degree to which those risks can be reduced at a reasonable cost.

The Agency estimated the risks associated with arsenic emissions from existing glass manufacturing plants and determined that most of the emissions and risks were associated with 11 uncontrolled furnaces emitting more than 0.4 Mg per year each. These furnaces are located at five different plants. A sixth plant, having nine furnaces, all of which emitted arsenic at a level below the proposed cutoff of 0.4 Mg per year, also had relatively high aggregate risks. Because of the proposed cutoff of 0.4 Mg/yr, however, none of these furnaces would have been subject to the proposed control requirements. Nevertheless, EPA considered whether the cutoff should be changed to require control of the emissions from these nine furnaces by estimating and analyzing the emission and risk reductions achievable and the associated costs and economic impacts. The analysis indicated that the cost of controlling emissions would be disproportionately high at this plant compared to the reduction of risk achievable.

Of the other five plants, three posed relatively high risks. The analysis indicated that the reduction in risk achievable from the first two plants is about three to four times greater than the reduction in risk that could be achieved from the third plant. Also, the costs of controlling emissions from the third plant are disproportionately high when compared to the reduction in risk which would be gained. For these reasons, the promulgated standard establishes an emission cutoff for existing glass melting furnaces that would require add-on control of emissions for only the first two plants. Emissions from both of these plants arise from arsenic-using glass furnaces which individually emit more than 2.5 Mg/yr (2.75 tons/year) of uncontrolled arsenic. Therefore, the cutoff on uncontrolled emissions of inorganic arsenic for existing glass melting furnaces is established at 2.5 Mg/yr (2.75 tons/yr). A more detailed discussion of the information on which this decision is based is included in Appendix D. Agency estimates indicate that there will be eight existing furnaces subject to the NESHAP.

The Agency does not evaluate risks to the general public based on OSHA occupational standards. The OSHA standards are set based on exposure to healthy workers during the 40 hour work week. The general public includes individuals at a greater risk than healthy workers (e.g., children, the elderly) and may be exposed continuously for a very long period of time.

Dr. Lamm testified at the public hearing concerning risks from arsenic emissions from the copper smelter in Ajo, Arizona. A response to this comment is found in the background information document for promulgated standards on primary copper smelters (EPA 450/3-83-010b).

2.2 STRINGENCY OF THE PROPOSED EMISSION LIMIT

2.2.1 Comment: One commenter (D-13) expressed support for EPA's emissions control proposal and emissions reduction targets, given that EPA concludes that arsenic emissions from the glass industry must be reduced.

2.2.1 Response: No response necessary.

2.2.2 Comment: One commenter (D-18) stated that the standards for emissions of arsenic from glass manufacturing plants should be more stringent than the 90 percent reduction on which the proposed standards are based. The commenter referred to data in the Background Information Document on the performance of electrostatic precipitators and fabric filters in controlling particulate matter emissions. These data, the commenter asserted, show that with only one exception fabric filters and electrostatic precipitators have control efficiencies greater than 90 percent. Setting the level of emissions reductions achievable by these technologies at the level of the least effective system does not satisfy the requirements of Section 112 of the Clean Air Act.

2.2.2 Response: It is the intent of the Agency to require the most effective possible control of arsenic emissions where these emissions may reasonably be expected to endanger public health. The proposed standards were not based on the achievability of 90 percent reduction of arsenic emissions from glass melting furnaces. Rather, the proposed standards required particulate emission from affected furnaces to be controlled to the established under the new source performance standards (NSPS) for glass manufacturing plants. These standards represent the level of control achievable through the application of the best demonstrated technology (BDT) for controlling particulate emissions from glass melting furnaces. Because the data available to the Agency at the time of proposal indicated that at least 90 percent of the arsenic emitted from glass melting furnaces would be emitted as particulate matter, it was believed that in meeting the NSPS particulate emission limits at least 90 percent of the emitted arsenic would be collected as well. As a result, the best available technology (BAT) for controlling arsenic emissions was determined to be identical to BDT for control of total particulate emissions. Therefore, the proposed standards were not based on the reduction of arsenic emissions achievable by the least effective system, but on the reductions in arsenic emissions achieved by the application of the best available technology. The 90 percent reduction cited in the background information document (BID) only reflects the minimum level of control for arsenic that was expected to be achieved through the application of BAT.

Data gathered by EPA after proposal, however, have indicated that in some instances significantly less than 90 percent of the arsenic emitted from glass melting furnaces is in particulate form. No correlations were identified between the proportion of arsenic emitted as particulate matter and the type of arsenic used as a raw material, the type of glass produced, or other process parameters.

In addition, EPA found that some furnaces, including the largest emitting furnace, could meet the proposed emission limits by reducing particulate emissions by as little as 45 percent. In this case, the corresponding reduction achieved in arsenic emissions would be no greater than 45 percent. For these reasons, it was concluded that the proposed emission limits would not guarantee that the most effective control of arsenic emissions would be achieved on all affected furnaces. In considering all of the available data, the Agency determined that a standard requiring arsenic emissions to be reduced by a specific percentage would be necessary to ensure that emissions control devices are installed and operated in a manner which best reflects their effectiveness in controlling arsenic emissions.

In setting the level of the final standard, consideration was given to the performance of existing control devices in reducing arsenic emissions, to the factors affecting control device performance, to the level of control achievable from uncontrolled furnaces, and to the costs of control. The data obtained on arsenic-using furnaces with existing controls indicated that the efficiency of these devices is variable, ranging from 92 percent to 99 percent. The data further indicate that the variability observed in control device performance does not correlate to the design or operating characteristics of either the glass melting furnace or the control device. Rather, the efficiency of these systems in reducing arsenic emissions is primarily a function of the amount of arsenic emitted as particulate matter. Although the available data do indicate that exhaust gas cooling may be effective in increasing the proportion of arsenic emitted as particulate matter, sufficient data are not available to predict quantitatively the extent to which cooling will increase the effectiveness of control.

As a result of these uncertainties, no technical basis exists for concluding that the efficiency of any existing control device could be improved by modifying either the design or the operation of the existing control system. In addition, the costs of modifying any existing control device would be disproportionate to the incremental reduction in arsenic emissions that might be achieved, even if there were reason to believe that these modifications would increase the effectiveness of control. Therefore, the Agency concluded that the standard should be set at a level which would not require any additional control of furnaces equipped with existing control devices.

Because of the variability observed in control device performance, and because no correlations exist between control device performance and process or operating characteristics, the efficiency of existing control devices in reducing arsenic emissions could not be generalized to furnaces that are not presently controlled. Therefore, emission testing was performed on the uncontrolled furnace that will be required to install controls under the promulgated standard. These tests (summarized in Appendix A) indicated that a maximum reduction in arsenic emissions of 85 percent could be achieved within the range of anticipated furnace production rates if the exhaust gas was first cooled to less than 121°C (250°F) prior to entering the control device. Because no methods for reducing uncontrolled emissions from this furnace by more than 85 percent (including further cooling) could be identified, and because all affected furnaces with existing controls have demonstrated removal efficiencies of 85 percent or more, the level of the final standard was established at a 85 percent reduction of uncontrolled arsenic emissions.

2.2.3 Comment: One commenter (D-18) stated that there is a discrepancy between the data concerning arsenic trioxide removal and the theoretical considerations relied on by EPA in setting the proposed standards. This commenter asserted that EPA found much more arsenic is removed from glass furnace flue gas by electrostatic precipitators than would be predicted by theory. Since the data support more stringent control requirements, EPA should not develop an emission standard that relies on this current theory.

2.2.3 Response: The standards were developed based on data collected by EPA which reflect the level of arsenic emissions reductions achieved by particulate matter control devices. The standards were not developed based on theoretical calculations of the anticipated emissions of arsenic. Indeed, if theory were relied upon, it would have been concluded that particulate matter control devices are ineffective in reducing arsenic emissions.

2.2.4 Comment: One commenter (D-17) stated that EPA has not proposed standards which address arsenic in the vapor phase or in fine particulate form. The commenter points out that arsenic trioxide is appreciably volatile at temperatures of 100°C (212°F), a temperature common to many industrial processes. Because arsenic trioxide sublimes from the solid to the vapor phase more rapidly than it condenses from vapor to liquid phase, flue gas may become supersaturated by arsenic trioxide, resulting in more vapor-phase arsenic trioxide than expected. Also, condensation of the vapor-phase arsenic will not occur as expected. Unless the process vapor is substantially saturated with arsenic trioxide, lowering the temperature will not force the vapor to condense. Therefore, control methods based on the condensation of arsenic trioxide will not be effective. Further, the commenter points out that arsenic trioxide adsorbs most readily onto small particulates, and that the removal efficiencies of particulate matter control devices are lower on fine particulates than on total particulates. The commenter concludes that fabric filters are the most effective technology in removing particulate matter emissions over a range of flue gas temperatures and particle sizes. Therefore, the proposed standards should be based on the performance of a well designed and maintained fabric filter system.

2.2.4 Response: Arsenic emissions from most glass manufacturing have been shown to be predominantly in the solid phase. Although this apparently contradicts theoretical considerations which predict that all of the arsenic would be emitted in the vapor phase, theoretical considerations do not take into account the presence of other chemical species in the stack gases. Therefore, EPA has not relied on theoretical data in developing this NESHAP. Rather, EPA has conducted a series of tests on glass furnaces to provide an indication of the physical form in which arsenic emissions occur, and to assess the effect of temperature on the proportion of arsenic found in the solid phase. In most tests, more than 90 percent of the arsenic has been shown to exist in the solid phase at typical stack gas temperatures of 288°C (550°F).

One test conducted on a furnace melting soda-lime glass indicated that a relatively small percentage (∿40%) of total arsenic exists in the solid phase at 288°C (550°F). When the filtered gases were cooled to 121°C (250°F), however, up to 80 percent of the total arsenic was found in the solid phase. In this instance, condensation did appear to occur even though the vapor-phase concentration at 288°C (550°F) was less than 1.0×10^{-6} of the theoretical vapor-phase concentration at saturation at that temperature. The results of this test were inconclusive, however. Although the amount of solid-phase arsenic increased as the filtered gas temperature in the sampling train was cooled from 288°C (550°F) to 121°C (250°F), the amount of vapor-phase arsenic did not decrease proportionally. Therefore, it is not certain that the increase observed in the amount of solid-phase arsenic captured in the sampling train occurred as a result of condensation of vapor-phase arsenic. Another emission test performed by EPA on a soda-lime glass furnace showed that all of the arsenic emitted from the furnace was in the solid phase regardless of temperature.

In another test on a glass melting furnace, additional information was obtained by EPA on the factors affecting condensation of gaseous arsenic. Both Reference Method 108 samples at 121°C (250°F) and single-point samples at elevated temperatures (204°C and 288°C) were collected during this test. In addition, backup filters maintained at 121°C (250°F) were placed prior to the impingers in some high temperature sampling trains. The fraction of arsenic detected in the Reference Method 108 sampling trains averaged 39 percent. The fraction of arsenic detected on the filters at 204°C (400°F) averaged 34 percent and an average of 36 percent of the total arsenic was collected on the filters at 288°C (550°F). These data indicated that condensation of gaseous arsenic was not occurring, even though the concentration of gaseous arsenic was relatively high. However, substantial amounts of arsenic were collected on the backup filters maintained at 121°C (250°F) in the high temperature sampling trains, which indicated that condensation did occur between the high temperature filters and the low temperature backup filters. These data suggest that the rate of condensation in the sampling train may be sensitive to residence time, temperature gradient, and/or probe location.

Although EPA agrees that the removal efficiencies of particulate matter control devices are lower for the smallest particle sizes, EPA is not aware of any data to support the contention that fabric filters are universally more effective in controlling arsenic emissions from glass melting furnaces than electrostatic precipitators (ESP). EPA has conducted three separate tests on controlled arsenic glass furnaces. Two of these were equipped with ESPs and the third with a fabric filter. The average control efficiency of the fabric filter in removing particulate arsenic was 99.7 percent. One of the ESPs demonstrated an average control efficiency of 99.6 percent, and the other achieved an average particulate arsenic removal efficiency of 99.0 percent. Therefore, the EPA has concluded that ESPs are as effective as fabric filters in controlling emissions of arsenic from glass manufacturing plants.

2.3 SELECTION OF CONTROL TECHNOLOGY

2.3.1 Comment: One commenter (D-12) stated that EPA should not assume that because a particular control device has been adequately demonstrated on one type of source, that it should be considered BAT for a different source category. EPA should consider only those control technologies that have been demonstrated at a commercial scale on a plant of the same type for which the control requirement is to be imposed. The commenter also stated that the definition of BAT should also vary among existing sources within the same general source category on the basis of the age and remaining useful life of the facilities. While a particular technology may be considered BAT for new plants, it may not necessarily represent BAT for older plants. The commenter endorsed EPA's approach of not regulating facilities where a level of control equivalent to BAT is already in place. Finally, the commenter stated that controls corresponding to BAT should not be imposed if they are not needed to eliminate a significant health risk, particularly in cases where a less costly technology will effectively eliminate all risks of mortality or serious illnesses.

2.3.1 Response: The selection of ESPs and fabric filters as the basis for the standard for the control of arsenic emissions from glass manufacturing furnaces is not based on assumptions, but on the actual experience of the glass industry in using these technologies to control arsenic emissions. The promulgated standard is set at a level that will require installation of emission control devices on only those existing glass furnaces where emissions of inorganic arsenic have been determined to present a significant risk to public health.

2.3.2 Comment: One commenter (D-18) objected to the EPA's reliance on compliance with OSHA standards for fugitive emissions of arsenic in the workplace in deciding not to propose standards for these emissions. The commenter stated that (1) this reliance was based solely on statements made by company representatives and had not been independently verified by the Agency; (2) although OSHA standards, if implemented, may provide protection to workers in glass manufacturing plants, they do not give persons living around the plants the enforcement power to compel compliance with the standards that would be available under the Clean Air Act; (3) the Agency should, at the least, incorporate into a Section 112 standard the equipment and work practice requirements needed to comply with the OSHA standards.

2.3.2 Response: The Administrator believes that where standards established under separate authorities are effective in reducing emissions, redundant standards need not be established by EPA. The Agency establishes separate standards when there is evidence that either the control measures are not likely to remain in place or are unlikely to be properly operated and maintained. EPA has again reviewed the emission sources at glass manufacturing plants to determine any need for controls beyond those required by OSHA.

Information gathered after proposal during visits to glass plants that use arsenic indicated that fugitive emissions from some plants may not be controlled. As a result of this finding, EPA has estimated the magnitude of the emissions of arsenic which could arise from fugitive sources within glass manufacturing plants. (Docket reference IV-B-11) These estimates were based on published fugitive emissions factors for various material handling operations, as well as on data gathered during visits to glass plants which use arsenic. To be conservative, "worst case" conditions were assumed in estimating potential fugitive arsenic emissions. For example, in this analysis it was assumed that the plant uses unusually high concentrations of arsenic (14 lb/ton) in the batch raw materials. The major potential source of fugitive particulate emissions at glass manufacturing plants are the materials handling operations associated with the unloading, storage and weighing of the bulk raw materials. However, arsenic is not present during these operations. Arsenic is added later, just prior to mixing of the batch. Fugitive emissions of arsenic could occur during mixing of the batch materials, during the transfer of these materials to the furnaces, when the materials are charged into the furnace, and when control devices (if used) are emptied and the waste products removed for disposal or recycled back into the melting furnace. In considering all of the possible sources of fugitive emissions from glass manufacturing plants, and employing the best information currently available to the Agency, EPA estimated that the maximum fugitive emissions of arsenic from a large, 545 Mg/year (600 tons per day) plant would amount to 0.21 Mg/year (0.23 ton/year) if emission control devices were not used. For a plant of this size, uncontrolled stack emissions would be about 145 Mg/year (160 tons/year). The same plant, if controlled, would emit about 7 Mg/year (8 tons/year) out of the stack(s); fugitive arsenic emissions from a 545 Mg/day (600 tons/day) controlled plant were estimated to be 0.33 Mg/year (0.36 ton/year) under worst case conditions. Because all of the plants known to use arsenic have capacities less than 545 Mg/day (600 tons/day), and because the estimates summarized above are based on "worst case" assumptions, EPA has concluded that fugitive emissions of arsenic from glass manufacturing plants are negligible and do not endanger public health. Therefore, the promulgated standard does not require controls for fugitive arsenic emissions at glass manufacturing plants nor have OSHA requirements been incorporated into the promulgated standard as suggested by the commenter.

2.3.3 Comment: Four commenters (F-1, F-2, D-10, D-18) discussed the elimination of arsenic as a raw material in the manufacture of glass. Two commenters (F-1, D-10) stated that the use of arsenic in the manufacture of glass containers has been completely eliminated, and that there is no technical reason to use arsenic in the manufacture of glass container products. These two commenters posed no objection to a requirement that arsenic be eliminated from glass container manufacturing, as long as no additional administrative burdens were placed upon container glass manufacturers. One commenter (F-2) stated that the use of arsenic in the manufacture of pressed and blown glassware is essential and that no acceptable substitutes are currently available. Without arsenic, tableware glass tends to have an objectionable green tint. Another commenter (D-18) objected to the contention that the elimination of arsenic in pressed and blown glass manufacturing would have serious consequences for this sector of the glass manufacturing industry. This commenter stated that the only benefit to the glass industry stemming from the use of arsenic is that it improves the cosmetic qualities of the glass by making it clearer. This commenter asserted that cosmetic benefits are insufficient to justify public exposure to arsenic emissions and urged that the standards be amended to eliminate arsenic from the manufacture of pressed and blown glass. The commenter also stated that if there are specialized, non-substitutable uses for arsenic which rise above the level of cosmetics, then EPA should set a standard requiring extremely stringent controls for a small number of furnaces dedicated to such uses.

2.3.3 Response: Based on the public comments received and the information available before and after proposal of the standards, EPA has concluded that the container glass, flat glass, and wool fiberglass segments of the glass manufacturing industry do not use arsenic as a raw material in the manufacturing process. Because the promulgated standard applies only to furnaces that use arsenic as a raw material, no furnaces in the container, flat, or wool fiberglass segments of the glass industry would be affected. Owners or operators of furnaces that do not melt a glass in which arsenic is added as a raw material are not subject to the requirements of this NESHAP, including those for reporting and recordkeeping. If an owner or operator of a furnace in any of these segments of the industry were to begin using arsenic, the furnace would be subject to the standard.

Arsenic is used in the manufacture of some products in the pressed and blown segment of the glass industry, however. A case-by-case assessment of the potential to eliminate arsenic use was conducted by contacting all six major manufacturers of pressed and blown soda-lime glassware. (docket reference IV-B-13) Although some companies have been successful in removing arsenic entirely from their raw batch materials, other companies producing similar types of glass have been unable to obtain a product of acceptable quality when arsenic is removed. The qualities achieved by the inclusion of arsenic (clarity, elimination of unwanted color, etc.) are not just "cosmetic" in the sense that they have no economic value, but reflect certain physical attributes of the final product which are required by the consumer. Demand for these products is inherently connected to their physical appearance which, therefore, has a tangible economic value. The EPA expects that producers of pressed and blown glasswares will continue to try to eliminate arsenic from their batch recipes to avoid being subject to the requirements of this NESHAP. It is not clear, however, when (and if) these efforts will be successful. Because a requirement to eliminate the use of arsenic in the pressed and blown glass noncontainer segment of the industry could have severe economic impacts for some producers, it is not included in the final standard but will be evaluated as part of the 5-year review of the standard.

EPA considered banning the use of arsenic in those segments of the glass industry where arsenic is known to be no longer used by establishing a zero emission limit for certain segments of the glass industry. However, the promulgated standard does not ban the use of arsenic within any segment of the glass manufacturing industry. The decision not to ban the use of arsenic in the flat, container and wool fiberglass industry segments was made for two main reasons. First, the only available system for differentiating among the various segments of the glass industry are the Standard Industrial Classifications (SIC) devised and administered by the Department of Commerce. EPA has no assurance that all plants at which arsenic is used at present have been classified within the pressed and blown glass segment of the industry (SIC 3229). Therefore, placing a ban on the use of arsenic according to SIC categories might place an unfair and unintended burden on some individual plants.

Second, the decision to establish an arsenic NESHAP for glass manufacturing plants was made on the basis of the finding that atmospheric emissions of arsenic pose a potentially significant risk to human health. The health risks arising from individual glass plants were carefully evaluated in establishing the promulgated standard. Emissions of arsenic from plants producing container, flat, or wool fiberglass would pose the same risks as those from plants in the pressed and blown glass segment of the industry. Therefore, EPA sees no reason to establish a separate emission limit for plants producing container, flat, or wool fiberglass that is any different than that for pressed and blown glass.

Glass melting furnaces which do not at present use arsenic, but which will use arsenic in the future, would be considered to be modified furnaces under the general provisions of 40 CFR Part 61. These furnaces would then be required under the promulgated standard to install a control device if emissions of arsenic exceed 0.4 Mg/year (0.44 ton/year).

2.4 COST EFFECTIVENESS OF THE PROPOSED STANDARD

2.4.1 Comment: One commenter (F-2) stated that the costs of applying add-on control technology to furnaces producing tableware glasses are disproportionate to the resulting reductions in emissions.

2.4.1 Response: The EPA's analysis of the costs of applying the promulgated standards to the production of tableware glass indicates that the costs of the final standard do not have significant adverse impacts on the industry and are reasonable in light of the reductions in arsenic emissions and health risks achieved.

2.4.2 Comment: One commenter (D-13) stated that only glass furnaces which are at present uncontrolled should be subject to the proposed regulations because the most cost-effective emissions reductions can occur from these furnaces.

2.4.2 Response: The response to comment 2.1.2 explains why the Agency decided to establish emission cut-offs based on emissions prior to any control device for existing and new or modified furnaces rather than making the NESHAP applicable only to uncontrolled furnaces as the commenter suggests.

2.5 ECONOMIC IMPACT

2.5.1 Comment: One commenter (F-2) stated that the monetary costs required to comply with the standard would severely affect an already depressed market which is facing significant and increasing competition from foreign producers of glass tableware. Between 1979 and 1982, the compound growth in imports has been 6.8 percent, while growth in the domestic share of the market has declined by 0.4 percent. In addition, over the past ten years there has been a decline in real total dollar market value for the U.S. tableware industry. Two tableware manufacturers have recently closed plants. The strong U.S. dollar will continue to favor imports of glass tableware. The commenter stated that reducing emissions to the level proposed by the standard is estimated to cost $14.20/ton of glass. These costs would increase operating costs by over 2 million dollars/year. This represents an increase of 2.1 percent in production costs over 1982 levels, which would have decreased 1982 profits by 25 percent.

2.5.1 Response: The EPA recognizes that machine-made glass tableware manufacturers are facing competition from foreign producers of glass tableware; and in the economic analysis conducted after proposal, it was assumed that prices cannot be raised and that companies must absorb the control costs as decreased profits (See Appendix B). The costs cited by the commenter were for a specific plant owned and operated by the commenter. The cost and economic impacts of the promulgated standard were analyzed for this plant, and EPA concluded that they would be disproportionately high compared to the risk reduction that would be achieved through application of control technology. Therefore, the plant is one of several that would have been required to install controls under the proposed standard but, due to the revised emission cutoff for existing furnaces, would not be required to install emissions control devices under the promulgated standard.

The economic analysis indicated a potential closure for only one furnace currently using arsenic and emitting arsenic at a rate above the revised cutoff. Company representatives have informed EPA, however, that they plan to eliminate the use of arsenic at this furnace (Docket reference IV-E-58); therefore, it would not be affected by the standard. The EPA's analysis indicates that no other furnace closures would result from this NESHAP.

2.5.2 Comment: One commenter (D-13) stated the belief that some plants would close down if the proposed standard were promulgated.

2.5.2 Response: As mentioned above, EPA has reanalyzed the economic impacts and has raised the uncontrolled emissions cutoff for existing furnaces. Within the narrowed range of affected furnaces, EPA believes that there will be no furnace closures due to the promulgated regulation.

2.5.3 Comment: One commenter (D-18) stated that the "worst case" economic analysis conducted by EPA has been grossly exaggerated in reaching a conclusion that under certain conditions the proposed regulations could cause some furnaces to close. Further, the commenter stated that the assertion that the elimination of arsenic from pressed and blown glass would make U.S. manufactured glassware uncompetitive with glassware imported from countries which do not restrict arsenic use has not been supported by hard data or analysis. The commenter stated that if the regulations do impose a competitive disadvantage on U.S. glass manufacturers, other steps should be taken to protect their position, such as the imposition of duties on imports of arsenic containing glass.

2.5.3 Response: The revised economic analysis (Appendix B) of the promulgated standard explains that cost absorption (profit reduction) by producers, rather than cost pass-through to consumers, is more likely to result because of the competitive role of imports. Using this assumption, all control costs were analyzed as additions to baseline operating expenses. No closures are anticipated as a result of the promulgated standard.

The EPA's assertion that U.S. manufacturers of pressed and blown glass would be at a competetive disadvantage with foreign manufacturers if arsenic were eliminated is based on the fact that the properties that arsenic provides in the glass products have an economic value. Such properties as clarity and sparkle are desired by the consumer and, thus, are considered necessary for certain products to be competitive in the market. The economic value of these properties has not been quantified but is, nevertheless, real. The commenter's suggestion that duties be imposed on imports of pressed and blown glass that contain arsenic cannot be implemented because EPA does not have legislative authority to impose such duties or to take any similar measure to reduce possible competition to U.S. glassware manufacturers by foreign glass.

2.6 EXEMPTIONS AND ALLOWANCES

2.6.1 Comment: One commenter (D-13) requested that EPA include provisions for conducting normal maintenance on control devices. Most glass furnaces operate continuously for a period of years, while emission control devices require frequent maintenance. The commenter stated that the maintenance requirement on an electrostatic precipitator is about 144 hours/year and that a provision should be made for by-pass of the control device while maintenance is being conducted.

2.6.1 Response: EPA has investigated the cost and environmental impacts associated with performing routine maintenance on emission control devices installed on affected glass furnaces. (Docket reference IV-B-10) Two alternatives were considered. The first alternative would be to require the glass furnace to be shut down during these maintenance periods in order to avoid uncontrolled emissions of arsenic. The second alternative would allow furnace operators to by-pass the control device for a limited period of time for maintenance purposes. Emissions of arsenic during these periods would not be controlled. EPA analysis compared the increase in the costs incurred by a model manufacturing plant which would result from the first alternative to the increase in emissions which would follow from the by-pass alternative. In this analysis both large and small furnaces and high and low glass production costs were considered. In total, the cost and environmental impacts associated with the alternative requirements were evaluated for eight different cases.

In the first four cases the impacts were calculated for two furnace sizes (50 tons/day and 150 tons/day) and for two levels of specific arsenic emissions (0.05 lb arsenic/ton of glass produced and 1.00 lb arsenic/ton of glass). In the first four cases, relatively low glass production costs were assumed, on the order of $0.34/lb of product. The second four cases assumed the same furnace sizes and specific arsenic emission rates, but were based on the assumption of a glass with higher production costs of $1.90/lb. These values represent the low and high end of the ranges for actual glass furnaces which use arsenic. In all cases, it was assumed that the time required for maintenance of control devices is 144 hours/year.

The results of this analysis showed that a large furnace with a high arsenic emission rate could emit up to 0.41 Mg (0.45 ton) of arsenic during the 144 hours that the control device is by-passed. Small furnaces with low arsenic emission rates would emit 0.01 Mg (0.01 ton) of arsenic during this maintenance period. The costs of furnace shutdown were estimated to range from a low of $63,000 for a small furnace producing a low cost glass, to a high of $1,000,000 for a large furnace producing a high cost glass. Thus, the cost effectiveness of requiring all arsenic-using furnaces to be shut down while maintenance is carried out on emissions control devices would range from about $420,000 per ton of arsenic removed to over $47,000,000 per ton of arsenic removed.

Because the impacts of requiring furnaces to be temporarily shut down while maintenance is performed on emissions control devices would be excessive in some cases, and because the use of well maintained control devices is essential in effectively controlling arsenic emissions on a continuing basis, the promulgated standard allows emission control devices installed on furnaces affected by the standard to be by-passed for purposes of conducting necessary maintenance. EPA has also determined, however, that arsenic emissions from glass melting furnaces can be reduced by implementing certain work practices during maintenance periods. Therefore, the regulation requires owners or operators of affected furnaces to minimize arsenic emissions to the maximum extent practicable during periods when the control device is shut down for maintenance purposes. Each owner or operator of an affected furnace that wishes to by-pass the control device for maintenance purposes is required to submit a plan to the Administrator which details (1) the length of time it will be necessary to by-pass the control device, (2) the emissions of arsenic which would occur during maintenance periods if no steps were taken to reduce them, (3) the procedures and work practices which will be implemented to minimize arsenic emissions during maintenance periods, and (4) the expected reduction in emissions of arsenic achieved by the implementation of these procedures and work practices. Only after approval by the Administrator of this plan will the by-pass of an emission control device be allowed.

In some cases, emissions of arsenic can be prevented entirely while control devices are undergoing maintenance. For example, control device maintenance could be scheduled during periods of normal furnace shutdown whenever possible. For some plants, it may be feasible to switch production temporarily during periods of control device maintenance to glasses which do not contain arsenic. All facilities affected by the regulation should make maximum use of control devices which are divided into two or more independently operated sections. Use of so called "sectionalized" control devices enables maintenance to be performed on one section of the device without affecting the operation of the other(s). Other steps that can be taken to minimize emissions of arsenic during maintenance of control devices are the maximum use of cullet, the temporary reduction in arsenic feed, or the temporary reduction of furnace output.

2.6.2 Comment: One commenter (D-13) requested that furnaces melting arsenic-containing glasses over limited time periods (1 to 10 weeks) for research and development purposes not be subject to the standard. Only after a glass is commercially proven and melted for production purposes should the glass/furnace become subject to the regulation.

2.6.2 Response: New or modified glass manufacturing furnaces emitting more than 0.4 Mg (0.44 ton) of arsenic per year or existing furnaces emitting more than 2.5 Mg (2.75 tons) per year are subject to regulation without regard to the purposes of the particular glass production. It is not anticipated that research and development furnaces will exceed the cutoffs. However, should emissions from a research and development furnace exceed these levels, the furnace would be subject to the standard. Whether the glass is produced as a research project or for sale, the arsenic emissions pose the same hazard and may be controlled through the application of the same control devices. Therefore, no exemption is provided in the final standard for research and development glass production.

2.6.3 Comment: One commenter (D-13) requested that, in those cases where production is shifted from a controlled furnace to an uncontrolled furnace, sufficient time (24 months) be allowed for installation of a control device. The commenter considered it unrealistic for the industry to anticipate the need to switch furnaces 2 years in advance in order to have a control device installed at start-up.

2.6.3 Response: The promulgated standards do not provide for an interim period following the switching of an existing furnace to the production of arsenic-containing glass to allow for the installation of control equipment. Basically, the switching of a furnace is viewed as similar to the construction of a new furnace and the same degree of planning prior to the change should be undertaken. Section 112 provides for the possibility of a 2-year waiver period only for existing sources of arsenic emissions.

2.6.4 Comment: One commenter (D-13) stated that because the grain loading from electrically boosted furnaces is on the order of 0.05 grains/dscf, an add-on control device may not be able to meet the standard for these furnaces at all times. It was noted that there are no add-on emissions control devices currently in use on electrically boosted glass furnaces. The commenter suggested that EPA may need to establish a separate category to reflect this.

2.6.4 Response: The comment is assumed to imply that the efficiency of particulate matter control devices will be adversely affected by low concentrations of particulates in the stack gases. As the commentor noted, there are no electrically boosted furnaces currently in operation which are equipped with an add-on control device. Therefore, EPA has no means to determine whether an electrically boosted furnace would be able to meet the proposed particulate limit at all times. No information has been submitted to EPA, however, that would indicate that electrically boosted furnaces would be unable to do so if equipped with an appropriate control device. EPA did test one electrically boosted furnace in the development of this NESHAP. The average particulate grain loading from this furnace was 0.11 gr/dscf, more than double the concentration cited by the commenter. Although electric boosting decreases the amount of particulate matter emitted, it also decreases the flow rate of the furnace exhaust. As a result, electric boosting is expected to have only a minor impact, if any, on the concentration of particulate matter at the inlet of the control device or on the emissions reduction efficiency of the control device.

Results of tests conducted by EPA in the development of this NESHAP have demonstrated that ESPs and fabric filters can achieve high arsenic collection efficiencies even when the concentration of arsenic in the flue gas is low. Average particulate arsenic removal efficiencies of 97.8, 99.7, and 99.7 percent were achieved by control devices on particulate arsenic inlet concentrations of 0.024, 0.006, and 0.01 gr/dscf, respectively. Because no data have been presented which indicate that emissions from electrically boosted furnaces cannot be controlled as efficiently as emissions from conventional furnaces and because ESPs and fabric filters are capable of high pollutant removal efficiencies even at low pollutant inlet concentrations, EPA sees no reason to establish a separate category for electrically boosted glass melting furnaces.

2.6.5 Comment: One commenter (D-13) recommended that the non-arsenic portion of the particulate emissions reduced in complying with the proposed standard should be available for future bubbling purposes allowed by State regulations. For example, the commenter stated that for a furnace emitting 7 lb/hour of total particulate, including 1 lb/hour of arsenic, that is required to reduce its arsenic emission to 0.1 lb/hour, the corresponding reduction in total particulates of 5.4 lb/hour should remain available for future bubbling purposes. The commenter stated that the state agencies should have this option.

2.6.5 Response: The availability of particulate matter emission reductions achieved under the NESHAP for "bubbling" is an issue outside the scope of this rulemaking, and is therefore not being addressed here.

2.7 MONITORING AND MEASUREMENT METHODS

2.7.1 Comment: One commenter (D-6) supported the EPA's position that a material balance or other non-stack test data be used to establish whether a facility is affected by the proposed regulation and to monitor compliance. However, the commenter requested clarification on two points. First, what confidence level does EPA have in the estimates of arsenic retention in glass? Specifically, should the low end of the estimate, 70 percent retention, be used in estimating uncontrolled arsenic emissions? Second, how should the arsenic content of the cullet be determined? Is it accurate to assume that all of the arsenic entering with the cullet remains in the glass, and thus has no impact on arsenic emissions?

2.7.1 Response: The estimates of the amount of arsenic retained in the glass product were provided by the glass industry. Data obtained from tests conducted by EPA have been found to be reasonably consistent with data supplied by industry representatives. It should be noted, however, that the amount of arsenic retained in the glass can vary significantly according to the specific recipe used in making the glass.

The 70 percent retention value published in the proposal BID (EPA-450/3-83-011a) was supplied by industry representatives as a typical retention rate for lead silicate type glass. Data gathered by the EPA after proposal have demonstrated that at least 70 percent of the arsenic is retained in the glass product regardless of its composition. However, the amount of arsenic retained in the glass product is not strictly a function of the type of glass produced. For any given type of glass, the percentage of arsenic retained in the product can vary widely. For example, data collected by EPA show that the percent of arsenic retained in soda-lime glass can range from about 70 percent to about 90 percent. Therefore, in estimating uncontrolled arsenic emissions, the arsenic retention value should be based on actual laboratory analysis of the glass produced in a specific melting furnace. If analytical data are not available, an assumed retention value of 70 percent would provide an estiamte of the maximum rate of uncontrolled arsenic emissions from a glass melting furnace. In developing a material balance for monitoring compliance, it is the responsibility of the furnace owner or operator to provide a theoretical emission factor which accurately takes into account the amount of arsenic retained in the glass. Retention values should be based on actual analytical data for the specific type(s) of glass produced by the furnace.

The amount of arsenic entering the furnace in the cullet should be explicitly accounted for. Some furnaces may add mixed cullet that is not exactly similar in chemical composition to the type of glass being melted.

When the cullet added is identical to the glass being produced, the percentage of arsenic in the cullet can be assumed to be identical to the percentage retained in the glass. Thus, the arsenic entering with the cullet would not have any impact on arsenic emissions. When this assumption is made, however, care must be taken to calculate the amount of arsenic retained in the glass on the basis of the percent of product weight that is derived from fresh raw materials rather than on the basis of the total product weight.

For example, consider a hypothetical furnace which produces 2000 pounds of glass per hour. Each 2000 pounds of product is made from a batch composition which consists of 1700 pounds of fresh batch materials, including 0.3 pound of arsenic, and 500 pounds of cullet. The cullet is identical in composition to the product and contains 0.012 percent arsenic. Thus, the total amount of arsenic entering the furnace per hour is 0.36 pound (0.3 lb/hr + [0.00012 x 500 lb/hr]). The amount of arsenic retained in the product per hour is 0.24 pound (2000 lb/hr x 0.00012). On this basis the expected emissions of arsenic from the furnace would be 0.12 lb/hour (0.36 lb/hr - 0.24 lb/hr). However, if the amount of arsenic entering with the cullet is ignored, then the portion of the total product that is derived from the cullet must also be ignored in determining the expected emission rate. Thus, if the total arsenic input is assumed to be 0.30 lb/hr (the amount of arsenic added in the fresh batch) then the amount of arsenic retained in the product per hour would be 0.18 lb/hour ([2000 lb/hour - 500 lb/hr] x 0.00012). This procedure yields the same expected emission rate as that obtained when the cullet arsenic is explicitly accounted for. It would be erroneous, on the other hand, to assume that of the 0.30 lb/hour of arsenic added to the fresh batch, 0.24 lb/hour is retained in the glass.

2.7.2 Comment: Two commenters (F-2, D-13) stated that the proposed requirement for opacity monitoring is unnecessary and inconsistent with the NSPS for glass manufacturing, which does not require opacity monitoring. One commenter (F-2) indicated that opacity monitoring would represent an unjustifiable cost burden. The other commenter (D-13) stated that opacity monitoring is administratively burdensome, and readings cannot be correlated with emissions of either arsenic or particulates, especially when multiple furnaces are exhausted to a common stack. The commenter noted that excessive stack opacity occurs in one of the commenter's furnaces as a result of gaseous fluoride emissions from melting one type of glass, and that this opacity is unrelated to arsenic or total particulate emissions.

2.7.2 Response: The requirement for opacity monitoring was proposed as a means to ensure that emissions control devices installed on arsenic-using glass furnaces are continuously operated and maintained in a manner consistent with the procedures followed to comply with the standard initially. These requirements have been retained in the promulgated standard. The fact that opacity monitoring is not required as part of the NSPS for glass manufacturing plants has no bearing on this action because the intent of this regulation is to control a hazardous air pollutant which is not specifically regulated under the NSPS. With respect to the costs of opacity monitoring, EPA has determined that the costs involved are reasonable in light of the improved effectiveness in enforcement that will be gained as a result of this requirement. No information has been presented to the Agency which indicates that continuous monitoring of opacity represents an unjustifiable cost burden.

The promulgated standard does not set any specific limit on stack gas opacity based on correlations between opacity and emissions of either particulate matter or of arsenic. Rather, the promulgated standard requires that a 6-minute average opacity value for a given furnace be determined during compliance testing. Any subsequent exceedance of the average opacity value demonstrated in a compliance test must be reported semiannually. If excess opacity occurs as a result of a change in the composition of the glass being melted in a furnace, this cause should be cited in the report. Alternatively, if multiple types of glass are typically melted in a single furnace, and stack gas opacity is expected to be significantly higher for one type of glass, the initial compliance test may be performed while this glass is being melted. Finally, paragraph 61.163(i) of the promulgated standard allows owners or operators of affected furnaces to petition the

Administrator for approval of any alternative continuous monitoring system that can be demonstrated to provide accurate and representative monitoring of a properly operating control device.

2.7.3 Comment: Two commenters (D-1, D-3) stated that the inclusion of a procedure for measuring sulfur dioxide in the flue gases from glass manufacturing is unnecessary. One commenter (D-1) further indicated that the procedure specified for sampling sulfur dioxide may give inaccurate results when applied to glass melting furnaces because of the formation of nitric oxide and sulfur trioxide in the manufacture of glass. The nitric oxide will be measured as sulfur dioxide because the analytical procedure is non-specific; it is a general test for all acidic species formed by passage through the hydrogen peroxide impingers. In conclusion, the commenter recommended that all references to the measurement of sulfur dioxide be eliminated in the description of EPA Method 108 procedures. The other commenter (D-3) indicated that the use of three hydrogen peroxide impingers is unnecessary, and that much of the currently available source sampling equipment cannot accommodate a six impinger sampling train. The commenter recommended that sulfur dioxide sampling be eliminated from the testing procedure for glass manufacturing plants.

2.7.3 Response: The three hydrogen peroxide impingers at the back of the sampling train were included only to protect the metering system from corrosion when sampling gas streams with high sulfur dioxide concentrations. The analysis steps for measuring sulfur dioxide were included to allow the tester to determine the approximate sulfur dioxide concentration so that the final sample volume could be corrected for the sulfur dioxide collected by the sampling train. However, neither of these steps would be necessary in collecting samples from glass furnaces so all references to sulfur dioxide collection and analysis have been deleted from the method.

2.7.4 Comment: One commenter (D-3) recommended that EPA establish greater consistency in specifying sampling probe and filter temperatures for EPA Reference Method 5 particularly for source categories that do not emit significant concentrations of sulfur dioxide. The commenter pointed out that a probe and filter temperature of 320°F was recommended for boilers

(NSPS), while a probe and filter temperature of 350°F was specified for glass melting furnaces (NESHAP). The commenter saw no reason to differentiate between sources firing more than, or less than, 0.5 percent by weight sulfur content. The commenter recommended that a set probe temperature be specified rather than a range, since the ratio of the front-half to back-half catch can vary significantly according to sample collection temperature. Finally, the commenter stated that comments previously made in response to Document No. A-81-19 relating to proposed Quality Assurance revisions to Methods 6 and 7 of 40 CFR, Part 60, Appendix A, as published in the Federal Register on March 30, 1983, are applicable here as well, and should be considered.

2.7.4 Response: Because the proposed particulate matter emission limits have not been retained in the promulgated standard, EPA Reference Method 5 sampling procedures are no longer applicable. Therefore, the temperature requirements referred to by the commenter are no longer relevant to this action. The Agency agrees that there is no reason to differentiate between sources firing fuel with greater than 0.5 percent by weight sulfur and those with less than 0.5 percent, and has revised the standard accordingly.

The commenter referred to comments made on the quality assurance and quality control revisions proposed for Reference Methods 6 and 7 in the March 30, 1983 Federal Register (48 FR 13388). He felt comments made on the proposed revisions to Reference Methods 6 and 7 were applicable to the requirement for an audit sample in Reference Method 108. The EPA promulgated the quality assurance and quality control revisions to Reference Methods 6 and 7 (49 FR 26522) on June 27, 1984. Comments and Agency responses are summarized in the promulgation notice.

This commenter (D-3) referred to the comments on Reference Methods 6 and 7, applying them to Reference Method 108, noting that an audit per set of compliance samples is over-regulation. The proposed quarterly (Reference Method 6 and 7) exemption covers repetitive testing at a given source only. Most control agencies will have a central laboratory and will use different personnel and analytical systems. The arsenic analyses are very time consuming, and a team of chemists may be routinely assigned to analyze the samples so they can be completed in a timely manner. The requirement that only one person analyze arsenic samples (paragraph 4.4) could delay the preparation of the compliance test report past deadlines now set by the States and EPA. The proposal should be amended to allow more than one person to analyze the samples. Any analytical variations would be checked by quality control procedures currently incorporated in EPA methods (e.g., equipment calibrations, duplicate testing and analysis, and inter-laboratory testing). Furthermore, since the "oneness" rationale is not and should not apply to the sample collection phase, it should not be mandated for the analyst and analytical equipment phase.

The comments on Reference Method 6 and 7 went on to say that the rulemaking ignores the logistical problems that will be created with a one-on-one audit requirement, especially for control agencies conducting numerous tests.

1. How will EPA guarantee delivery of the audit samples?

2. Will EPA ensure that the concentrations are within the analytical range of the samples?

3. Can it ensure a different audit concentration for each request?

4. Can EPA guarantee fast delivery of audit samples? Our regulations require analysis within 48 hours of sample collection.

In response to these comments on Reference Method 6 and 7 and their applicability to Reference Method 108, the quarterly auditing allowance for analyses performed on a frequent basis has been changed. The revised requirement (Reference Method 6, 7 and 108) is to analyze audit samples at least once per month. This discourages the use of 3 month-old analytical reagents as allowed in the quarterly audit and also eliminates the need to perform an audit with each set of compliance samples if samples are analyzed on a frequent basis.

The intention of the rule is not to restrict the analysis to one person but rather to ensure that all parties involved in the analysis of the compliance samples likewise take part in the analysis of audits. The names of all persons participating in the audit analysis are to be included in the report that is submitted to the appropriate enforcement agency.

EPA will be able to respond if notified soon after a decision has been made to perform a compliance test. The quality assurance revisions will have instructions to notify the EPA Quality Assurance Management Office 30 days prior to the actual test.

Since all sample concentrations must be diluted to fall within the calibration range of the standards for Method 108, the audit sample concentrations will be within these analytical ranges. Coordination within the auditing program will ensure that sources receive different audits on different requests.

2.7.5 Comment: One commenter (D-7) stated that the acid digestion bombs required by the Method 108 protocols are a potential explosion hazard, and recommends that alternative methods be developed. The commenter also noted that since a five hour digestion period is specified by the methods, it would be desirable to have multiple bombs in order to digest several samples simultaneously. However, since these bombs are expensive, small air pollution laboratories could incur significant expense in obtaining multiple bombs.

2.7.5 Response: A review of data collected at glass furnaces shows that there is little or no arsenic in the insoluble particulate matter which must be digested by the bomb digestion procedure. Although significant amounts of arsenic can be found in the insoluble particulate from copper smelters, the digestion procedure will be eliminated from Method 108 when it is applied to glass furnaces.

2.7.6 Comment: One commenter (D-13) stated that the time allowances for testing under the proposed Section 61.163 were inflexible and inadequate, and that the specified testing procedures were inflexible and unnecessary. In support of this view, the commenter provided data showing that other analytical methods can provide similar results to those obtained when using the specified EPA Method 108 procedures.

The major difference between the procedure proposed by the commenter and the EPA Method 108 procedure was in the method used in determining arsenic concentration of the samples. The procedure proposed by the commenter employed the colorimetric molybdenum blue method instead of atomic absorption. There were also slight differences in the types of reagents employed, and the procedures followed, in leaching the materials collected by the probe, filter, and impingers. In the example provided, the amount of arsenic detected when using the molybdenum blue method was 21 mg, 5 mg, and 0.2 mg in the filter, probe, and impingers, respectively. These results compared to detected arsenic levels when using EPA Method 108 procedures of 21 mg in the filter, 1 mg in the probe, and 0.4 mg in the impingers.

2.7.6 Response: Under Section 40 CFR 61.14 in Subpart A - General Provisions, the Administrator may allow the use of any alternative method which he has determined to be adequate for indicating whether a source is in compliance. Anyone wishing to have a method approved as an alternative may submit comparative data between the candidate method and the reference method for evaluation by the Administrator. EPA has notified the commenter of these provisions (docket reference).

2.8 DETERMINATION OF COMPLIANCE

2.8.1 Comment: One commenter (D-13) stated that not all furnaces that are at present controlled can be assumed to meet the proposed standard. For example, a controlled furnace at one of the commenter's plants is in compliance with the proposed emission limits at low and medium production rates. The furnace has not been tested at high rates of production, however, and it is not known if the furnace would achieve compliance at high rates of production. The commenter stated that it would be costly and burdensome to test this furnace at artificially high production rates, and unnecessary in light of the fact that the control device installed on this furnace represents the best system available at present.

2.8.1 Response: Under the promulgated standards, it would not be necessary to test glass manufacturing furnaces at artificially high production rates. Rather, for purposes of demonstrating compliance, testing will be performed at the typical expected production rate of a given furnace. Because the proposed limits on particulate emissions have not been retained in the promulgation standards, determinations of compliance for furnaces which are required to install control devices will not be affected by the production rate of the furnace. These furnaces must only demonstrate that emissions of arsenic are being reduced by the percentages specified in Section 61.162.

2.8.2 Comment: One commenter (D-13) provided an example of the difficulties that may arise in demonstrating compliance with the proposed emission limits for furnaces that are already equipped with control devices. The commenter provided a hypothetical situation in which a baghouse controls emissions from two furnaces which melt four different types of glasses, and three of these glass compositions contain arsenic. Each module of the baghouse has its own "goose neck" exhaust stack. The commenter states that these goose neck stacks cannot be tested using EPA Method 5 procedures, and cannot be equipped with opacity monitors. The commenter suggested that EPA should consider accepting the efficiency rating of the control device as specified by the manufacturer, in lieu of requiring emissions testing.

2.8.2 Response: Method 108 has replaced Method 5 as the required test method in the promulgated standard, but the sampling procedures in Method 108 would not be appropriate for testing the specific source cited by the commenter either. However, there is another test method, Method 5D, whcih was developed specifically for testing baghouses and whose sampling procedures would be applicable to this source. For sources equipped with positive pressure fabric filters, Section 4 of Method 5D should be used in conjunction with Method 108 to determine a suitable sampling location and procedure. Although it would be possible to equip a source such as this with opacity monitoring equipment, it would not be very cost effective since multiple opacity monitors would be required. A source could request an alternative procedure such as the one allowed at electric arc furnaces where daily observation of visible emissions (in accordance with Method 9) by a certified visible emissions observer is used to monitor opacity.

2.8.3 Comment: One commenter (D-13) raised the question of the applicability of the standard in cases where multiple furnaces are exhausted to a common stack. An example was given of a group of five furnaces which melt more than 30 different glass compositions, 9 of which contain arsenic.

These furnaces are controlled by two electrostatic precipitators which exhaust to a common stack. The commenter stated that more than 100,000 combinations of furnaces/glasses could occur on any given day. For this reason, it would be virtually impossible to determine if each combination is in compliance with the applicable proposed emission limit. Finally, the commenter indicated that the control devices installed on these furnaces reflect the best technology currently available, yet do not always comply with the proposed standards. The commenter provided another example in which a furnace melting fluoride opal glass is known not to meet the proposed emission limits at all times even through the furnace is controlled with the Best Available Technology (BAT). The commenter stated that this situation is attributable to EPA's classification of fluoride opal glass in the "all other" category during NSPS development. In conclusion, the commenter indicated that furnaces that are already equipped with BAT should not be subject to further regulation under the proposed standard.

2.8.3 Response: EPA has investigated the problems associated with demonstrating compliance with the proposed emission limits on total particulates in cases where multiple furnaces, producing different types of glass, are exhausted to a common stack. Because the proposed particulate emission limits varied according to glass type, the emission limit applicable to a given furnace would change with a corresponding change in the type of glass produced. No satisfactory approach could be developed for determining compliance with a particulate emission limit under these circumstances, or for prorating emissions from multiple furnaces which exhaust to a common stack when these furnaces melt various types of glass. Partly for this reason, the proposed emission limits on total particulates have been abandoned and replaced by a requirement that arsenic emissions be reduced by a specified percentage. (See response to comment 2.2.2.)

EPA also investigated the issue raised by the commenter in regard to the compliance status of furnaces which are equipped with existing control devices. In reviewing all available data on controlled arsenic-using glass furnace, the Agency has found that many of these control devices achieve more than 95 percent reduction of total arsenic emissions, although some of them are not capable of reducing emissions of total particulates to the levels prescribed by the proposed standard. The cost of upgrading these control devices to meet the proposed particulate emission limits was investigated and found to be excessive given the minimal incremental reduction in arsenic emissions that would be achieved. Therefore, basing the control requirement on the NSPS emission limits originally proposed would result in the failure of some furnaces with existing control devices to achieve the standard, even though these control devices represent an effective control for emissions of arsenic. For this reason also, the proposed emission limits have not been retained in the promulgated standard. Data made available to EPA from industry representatives indicate that all existing controlled furnaces with uncontrolled arsenic emissions of more than 2.5 Mg/year (2.75 tons/year) will be able to demonstrate compliance with the promulgated emission limits without additional control.

The EPA has investigated the emission reductions currently achieved from the furnace producing a fluoride-opal glass composition referred to by the commenter. The control device installed on this furnace was found to reduce arsenic emissions by more than 98 percent, although particulate emissions from the furnace exceed the applicable NSPS emission limits. As discussed above, the proposed emissions limits were not adopted in the final regulation, and no additional control is required on this furnace under the promulgated standard.

2.8.4 Comment: One commenter (D-26) stated that the provision in the proposed standards requiring emissions to be monitored only at the stack outlet and reported every 6 months is unenforceable. The commenter suggested that an efficiency standard for arsenic removal, which would require the measurement of arsenic levels at both the inlet and the outlet to the control device, or a standard limiting the amount of arsenic in each batch would be enforceable and would reduce arsenic emissions to the atmosphere.

2.8.4 Response: Although the commenter provided no information to support the contention that the proposed standard would have been unenforceable, the proposed emission limits on total particulates have been replaced in the promulgated standard by a requirement that emissions of arsenic be reduced by a specified percentage. In analyzing data made available after proposal, EPA found that particulate emission rates from some uncontrolled arsenic-using furnaces are significantly less than would normally be expected. Thus, these furnaces could conceivably meet the proposed limit on particulate emissions by reducing particulate emissions by as little as 45 percent. In this case, the corresponding reduction achieved in arsenic emissions would be only 40 to 45 percent even if all of the arsenic were emitted as particulate matter. In considering these data, EPA has found that emission control equipment that would meet the proposed particulate emission limits may not, in all instances, represent the most effective control technology for arsenic emissions. Therefore, the promulgated standard requires emissions of arsenic to be reduced by a specified percentage which reflects the level of control achievable by the most effective control technologies.

Setting a limit on the amount of arsenic added to the raw materials would constitute a work practice standard as defined in Section 112 of the Clean Air Act. Section 112 allows work practice standards to be set only in those instances in which it is not feasible to prescribe or enhance an emission standard. Because emission standards for arsenic from glass manufacturing plants can be established and enforced, EPA has no authority to establish a work practice standard. In any case, the amount of arsenic added to the raw materials varies widely within the industry as a function of the type of glass being produced and the market for the final product. Therefore, it would be impossible to set any specific limit on arsenic usage which could be applied to all glass melting furnaces, or to categories of glass melting furnaces, that would not fundamentally interfere with process operations.

2.9 REPORTING REQUIREMENTS

2.9.1 Comment: One commenter (F-2) stated that it is unreasonable and irrational to require 12-month projections of arsenic emissions from glass plants. A semiannual reporting of past emissions should be sufficient for enforcement purposes.

2.9.1 Response: The requirement that arsenic emissions be projected over a 12-month period is necessary in order for the operator of the glass manufacturing furnace to anticipate the level of control that will be required for each facility. Only in this way can possible instances of noncompliance with the proposed standards be prevented. The calculation of past emissions may reveal actual instances of noncompliance, but only after unacceptable levels of arsenic have been emitted to the atmosphere. This result would be inconsistent with the objectives of Section 112 of the Clean Air Act.

2.9.2 Comment: One commenter (D-13) stated that many administrative problems could result with EPA's semiannual reporting requirements under the proposed Section 61.163.

2.9.2 Response: The administrative problems referred to in this comment have not been specified. However, it is the EPA's conclusion that the reporting, recordkeeping, and other requirements contained in the standards are both necessary to the implementation of the regulation and reasonable in their impact on the glass manufacturing industry and individual furnace owners and operators.

2.10 ARSENIC EMISSIONS FROM SODA-LIME FURNACES

2.10.1 Comment: Three commenters (D-23, D-24, D-25) addressed the issue of whether the temperature of the gas exhausted from furnaces melting soda-lime glass affects the percentage of arsenic emitted in the solid phase, and the three options proposed by EPA for controlling arsenic emissions from soda-lime glass furnaces.

One commenter (D-25) stated that data from one of the commenter's soda-lime furnaces indicate that the percentage of arsenic in the solid phase increases with increasing stack gas temperature. He noted that the proportion of arsenic found in particulate from this furnace varied widely from a low of about 50 percent to a high of 99 percent. The commenter offered no explanation of why these data conflicted with the data gathered by EPA, but felt that there may be some complex chemical reactions taking place in the melting furnaces which are not at present understood. Data obtained from another of the commenter's plants (melting an "all other" glass type) have also shown a trend of increasing solid-phase arsenic with increasing stack gas temperature. For 23 representative samples collected on this furnace, from 30 to 100 percent of the total arsenic was emitted as particulate. The commenter concluded that temperature alone is not the only factor affecting the level of arsenic control achievable from glass melting furnaces.

The commenter (D-25) also responded to the options proposed by EPA for controlling arsenic emissions from soda-lime glass manufacturing furnaces. According to the commenter, a stack gas temperature of 250^{O}F is at, or below, the acid dew point for most exhaust streams and would lead to severe corrosion of control equipment. Corrosion problems would decrease the on-line availability of control devices leading to higher emissions of particulate arsenic than would occur if the temperature of the exhaust gas was maintained at a higher temperature. The commenter stated that dry scrubbing is not, in practice, a reliable technology. In the commenter's opinion, EPA should not require cooling of exhaust gas to 250^{O}F at the present time without at least first demonstrating the technology on a pilot scale. The commenter also noted that the dew point of exhaust gases from glass furnaces is constantly changing, and cannot be accurately monitored on a continuing basis. Also, temperatures profiles across an emission control device are not uniform. Therefore, maintaining the temperature of the exhaust gases at the inlet of the control device at 10^{o} to 20^{o}C above the dew point is not practical, and would not ensure that the temperatures within the control devices would not fall below the dew point. According to the commenter, a control option based on maintaining exhaust gas temperatures at 10^{o} to 20^{o}C above the acid dew point demands more from technology than current technology can provide. The commenter concluded that the reduction in arsenic emissions from soda-lime furnaces achievable with ESPs or fabric filters would, in practice, be much better than theory would suggest, and recommended that EPA test this hypothesis on a pilot scale before selecting any other regulatory option.

Another commenter (D-23) challenged the validity of the data presented by EPA in support of the options being considered for control of inorganic arsenic emissions from soda-lime glass furnaces. The commenter noted that, based on a concern over the data and information presented in the March 20, 1984 Federal Register notice, additional information was requested from, and provided by EPA. After receiving and thoroughly reviewing this additional information, the commenter concluded that the test data used by EPA were faulty, and also misrepresented in the March 20, 1984 notice in the Federal Register. Specifically, the commenter stated that Figure 1 was not a graph showing the percentage of arsenic in the solid-phase, but rather a graph showing normalized data produced from inaccurate test data. The commenter also noted that a meeting was held with EPA on April 12, 1984 to review the information provided by EPA. On the basis of that meeting, it was concluded by the commenter that the data were sufficiently flawed such that the conclusions presented by EPA could not be drawn. The commenter stated that the total measurements of arsenic emissions in each of the three tests showed a decreasing amount of total particulate, and that this could only be the case only if the sampling train failed to collect material. [The Administrator assumes that this commenter meant to refer to "total arsenic" rather than "total particulate".] The commenter found this position difficult to accept based on EPA's contention that the sampling train is 99 percent efficient in capturing gaseous and particulate emissions.

The commenter stated that if an arsenic emission limitation is to be placed on soda-lime glass melting operations, then it should be based on the effects of emissions on ambient air quality and on risks to public health. The method for meeting an established emission limitation should be left up to glass manufacturers. In conclusion the commenter urged EPA to review its earlier position that at least 90 percent control of arsenic emissions can be achieved by control equipment, a position that the commenter believes to be correct. The commenter also contended that sufficient time and resources have already been committed to the study of soda-lime glass melting operations and that further activities are unnecessary.

A third commenter (D-24) stated that the data presented by EPA demonstrate that emissions of particulate arsenic increase sharply as the temperature of the furnace exhaust gases decreases. This shows that substantial additional control of arsenic emissions can be achieved by cooling the gas stream prior to the particulate control device. Therefore, in reviewing the three options considered by EPA for controlling arsenic emissions from soda-lime glass furnaces, the commenter stated the belief that the option of not requiring any cooling should be rejected. The commenter noted that the drawback to the second option (require cooling to 10° to 20°C above the dew point of the furnace exhaust gases) is that the cooling requirement would need to be tailored to each facility which would increase the task of implementation and enforcement. This option is still preferable to requiring no cooling, however. The commenter expressed the belief that the best option is to require cooling of the furnace exhaust gases to 121°C, or to an even lower temperature. However, the commenter challenged EPA's conclusion that cooling to this temperature would mean that "most" operators would need to install dry scrubbers upstream of the particulate control device. The commenter noted that EPA neither presented nor referred to any data to substantiate this claim and that the Background Information Documents (BIDs) for smelters suggested that temperatures of 121°C or lower are tolerable. Nonetheless, the commenter supported the option of requiring operators to reduce exhaust temperatures to 121°C, even if scrubbers are necessary, because of the substantial reductions in emissions of arsenic achievable through gas cooling.

2.10.1 Response: Since the three options proposed by EPA for controlling arsenic emissions from soda-lime glass melting furnaces were published in the Federal Register (49 FR 10278), the Agency has performed two additional emission tests and has reviewed additional data provided by industry representatives. In considering all of the available data, EPA concludes that there is insufficient evidence to support a requirement that the exhaust gas from soda-lime glass furnaces, or from furnaces producing any other type of glass, be cooled to any specific temperature prior to entering a particulate control device.

The available data do indicate that arsenic emissions from some glass melting furnace may occur less predominantly as particulate matter than was previously believed, and that cooling can be effective in increasing the proportion of total arsenic emitted as particualte matter. However, no correlations have been identified between the proportion of arsenic emitted as particulate matter and the type of glass produced, the type of melting furnace used, the type of arsenic added to the raw materials, or any other source characteristics. In addition, EPA does not have sufficient data to conclude that cooling of furnace exhaust gases would be effective in increasing the efficiency of a control device in all cases. Therefore, a requirement that the exhaust gas from all affected furnaces be cooled to some specific level prior to entering a cotnrol device could result in increased costs with no guarantee that additional control would be achieved. The Agency does believe, nonetheless, that both the format and the level of the final standard are sufficient to ensure that furnace exhaust gases are cooled in those instances where the effectiveness of control is dependent on the operating temperature of the control device.

The results of the first test on a furnace melting soda-lime glass showed that less of the total arsenic emitted from the furnace was in particulate form compared to the previous tests (about 74 percent compared to more than 90 percent) at the standard EPA Method 108 sampling temperature of 121°C (250°F). In addition, samples taken simultaneously at three different temperatures (121°C, 204°C, and 288°C) showed that the amount of arsenic in the particulate matter generally increased as the filtered gas was cooled from 288°C (550°F) to 121°C (250°F). However, the amount of vapor-phase arsenic detected in these samples did not decrease in proportion to the increase observed in particulate arsenic, and the total amount of arsenic collected at 288°C (550°F) was uniformly less than the total amount collected at a filtered gas temperature of 121°C (250°F). The results of this test were also complicated by the fact that some of the filters used during the test were later found to be torn. Because there was not a decrease in vapor-phase arsenic emissions in proportion to the apparent increase in particulate arsenic, no basis exists for concluding that cooling of the exhaust gases caused vapor-phase arsenic to condense and form particulate arsenic. The Agency agrees with the commenter that the data obtained from the first test on a soda-lime furnace are inconclusive, and are insufficient to support a limit on the temperature of the gases at the inlet of particulate control devices.

After publication of the notice in the Federal Register on March 20, 1984, a second arsenic emission test was performed on a soda-lime glass melting furnace. No significant amounts of vapor-phase arsenic were found in the emissions from this furnace regardless of the temperature of the filtered gas. In all test runs, more than 99 percent of the total arsenic was captured as particulate matter. Therefore, even if the results of the first test on a soda-lime furnace had demonstrated a relationship between temperature and the amount of arsenic emitted as particulate matter, this relationship could not be generalized to all furnaces producing soda-lime glass.

The EPA also performed emission tests on a glass melting furnace producing an alumino-silicate glass. Although the furnace is not presently equipped with a permanent control device, a pilot-scale fabric filter system had been recently installed on the furnace. The test program included both EPA Reference Method 108 and single-point sampling, as well as a series of performance tests on the pilot-scale fabric filter. The results of these tests did conclusively demonstrate that cooling of the furnace exhaust gases caused gaseous arsenic to condense, and thereby increased the effectiveness of the fabric filter in reducing arsenic emissions. When the temperature of the exhaust gas was cooled to below 121°C (250°F), control efficiencies ranged from about 75 percent to 97 percent and averaged about 87 percent. When the temperature of the exhaust gas was maintained above 121°C (250°F), control efficiencies ranged from about 58 percent to 82 percent and averaged about 71 percent. The data also indicated that the effectiveness of cooling is sensitive to the concentration of gaseous arsenic in the exhaust gas and to the residence time of the gas stream at lower temperatures. However, the data collected during these tests are not sufficient to correlate specific temperatures to specific removal efficiencies.

Although the promulgated standard does not require exhaust gas cooling, EPA does believe that dry scrubbing is a demonstrated technology for control of emissions from glass melting furnaces. At least two manufacturers offer dry scrubbing systems for glass furnaces and eight dry scrubbing systems are known to be installed on glass melting furnaces. Both manufacturers and all eight plants were contacted for information on the performance, reliability, and costs of these systems. The information obtained from these contacts (Docket reference IV-B-14) indicates that dry scrubbing systems are a demonstrated technology for removing potentially corrosive pollutants from the exhaust gases of glass melting furnaces, and would enable cooling of the exhaust gases to a temperature of 121°C (250°F).

2.11 ZERO PRODUCTION OFFSETS

2.11.1 Comment: Two commenters (D-24, D-25) responded to EPA's proposal for revising the method of applying zero production offsets in determining compliance with the proposed particulate emission limits. One commenter (D-24) discouraged EPA from developing either tighter offsets, which would place existing control equipment in jeopardy of being out of compliance, or more complex offsets which would make it more difficult to obtain a meaningful guarantee from vendors of new control equipment. The commenter expressed the belief that the existing offset provisions are sufficient to adequately protect the environment, and that reducing or changing them will only result in miniscule reductions in emissions. At worst, changing the zero production offset provisions will result in trivial non-compliance situations, and uncertainty in engineering new control devices. The commenter concluded that EPA should have more important matters to pursue than worrying about a few tenths of a pound per hour of particulate emissions from small glass melting furnaces with an existing, or new, ESP or fabric filter control device.

One commenter (D-24) expressed support for EPA's analysis of the zero production offset issue. The commenter stated that these offsets were developed in an unrelated proceeding to suit a purpose which is neither controlling nor relevant to the development of a NESHAP for glass manufacturing plants. According to the commenter, retention of the offsets would allow higher emissions from some facilities than would occur if the offset provisions were dropped. Therefore, the commenter stated support for dropping the use of zero production offsets.

2.11.1 Response: The issue of zero production offsets would apply only to a standard which set a limit on emissions from glass melting furnaces specific to the amount of glass produced in the furnaces. However, the format of the standard has been revised to require affected furnaces to reduce arsenic emissions by a certain percentage. Therefore, the zero production offset provisions of the NSPS for glass manufacturing plants are not applicable to the requirements set forth in the final NESHAP.

2.12 RISK ASSESSMENT AND RISK MANAGEMENT

2.12.1 Comment: One commenter agreed with EPA's judgment that an arsenic emission standard is needed for glass manufacturing plants. The commenter characterized glass plants as sources of substantial arsenic emissions. They opposed the idea that glass manufacturing plants emit less than smelters EPA has proposed to exempt and should therefore not be regulated. The commenter offered three reasons for not exempting glass manufacturing plants from the regulation: (1) the commenter believed that the proposed smelter exemptions were unlawful and unwise; (2) the commenter contended that section 112 of the Clean Air Act requires EPA to set standards for all arsenic source categories; and (3) the commenter saw the opportunity to reduce or eliminate 37 Mg/yr of arsenic as substantial and not to be ignored.

A contrary view was offered by two other commenters. They called arsenic emissions from the entire glass manufacturing industry insignificant because glass manufacturing contributed only 3 percent of the total arsenic emissions. One commenter asked how EPA could conclude that 37 Mg/yr from the entire glass industry represents an "unreasonable risk" while simultaneously finding that emission rates of 627, 172 and 140 Mg/yr from individual copper smelters after control by the proposed standards are reflective of an ample margin of safety.

2.12.1 Response: The Agency noted that the above commenters focused their reasoning to regulate or not regulate glass manufacturing plants on the arsenic emissions from the various plants and source categories. In an approach that is sometimes used by the Agency, the commenters are using emissions estimates as a surrogate for ambient concentrations and public exposure on which risk assessment is based. However, surrogates must be carefully applied and the underlying assumptions that make the use of surrogates reasonable techniques must be carefully considered. For example, when comparing emissions from different sources as a surrogate or substitute to comparing public exposure, the commenter is assuming that similar emissions cause similar ambient concentrations, that is, emission parameters for and population distributions near each source or source category are similar. The commenters' comparison of the arsenic emissions from copper smelters to glass manufacturing plant emissions is a case of where the surrogate approach breaks down. In this case, primary copper smelters emit a large portion of their emissions from tall stacks and thereby create relatively small concentrations around the plant. Unlike the smelting industry, glass manufacturing plant emissions are coming from relatively low stacks and are causing larger ambient concentrations per ton of emissions than the primary copper smelters. And, indeed, EPA air dispersion modeling has borne this out. So, EPA cannot determine the need to regulate or not regulate the glass manufacturing plants by comparing glass plant emissions to the primary copper smelters emissions; EPA analysis has shown that this approach would lead to faulty decisions when protecting public health.

2.12.2 Comment: One commenter estimated that one of his glass plants (at Shreveport) contributes 0.16 $\mu g/m^3$ arsenic averaged over 8 hours, and he called this an insignificant environmental impact.

2.12.2 Response: Based on the Agency's calculations, the maximum concentration to which people near this plant are exposed is 0.018 $\mu g/m^3$ averaged over several years. Although EPA has not calculated an 8-hour average concentration, it appears that the two estimates are reasonably consistent when considering the difference in averaging times. The Administrator believes that the risk associated with Shreveport plant's arsenic emissions is low.

APPENDIX A

SUMMARY OF RESULTS OF EMISSIONS TESTING PERFORMED AFTER PROPOSAL

A.1 SUMMARY OF EMISSION TESTING ON A SODA-LIME FURNACE

A.1.1 Introduction

Emission tests were conducted on a soda-lime glass melting furnace in July 1983. Arsenic was being added to the batch raw materials in the form of powdered arsenic trioxide. Emissions from the furnace were not controlled. Two different types of emission tests were performed. First, in order to evaluate whether the temperature of the furnace exhaust gases has an effect on the proportion of arsenic emitted in the solid phase, a series of three single point tests were conducted. In the single point testing, three sampling trains were operated simultaneously. In each train, the filtered gas was maintained at a different temperature: one at 121°C (250°F), one at 204°C (400°F), and one at 288°C (550°F). Second, four modified EPA Method 108 tests were performed. The results of these tests are presented below.

A.1.2 Summary of Single Point Tests

Table A-1 summarizes the results of the single point sampling. The values given for the S-1-A and S-2-A results are suspect because small tears were identified in the filters used when these samples were taken. Nonetheless, the proportion of solid-phase arsenic appears to increase as the filtered gas temperature is cooled from 288°C (550°F) to 121°C (250°F). In run S-3, a three-fold increase in solid-phase arsenic occurred as a result of cooling the gas stream. The amount of vapor-phase arsenic present did not, however, decrease in proportion to the increase in solid-phase arsenic. In run S-3, vapor-phase emissions decreased by about half when the filtered gas temperature was reduced from 288°C (550°F) to 121°C (250°F). In runs S-1 and S-2, the amount of vapor-phase arsenic detected remained roughly constant at all temperature levels. Because the amount of

TABLE A-1. SUMMARY OF SINGLE POINT TESTS ON A SODA-LIME FURNACE

Run ID	Sample Temp (°F)	Arsenic Emissions Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Solid (%)
S-1-A	250	0.00141	0.00153	0.00294	47.96
S-1-B	400	0.00144	0.00133	0.00277	51.99
S-1-C	550	0.00097	0.00155	0.00252	38.49
S-2-A	250	0.00217	0.00109	0.00326	66.56
S-2-B	400	0.00161	0.00090	0.00251	64.14
S-2-C	550	0.00069	0.00123	0.00192	35.94
S-3-A	250	0.00343	0.00074	0.00417	82.25
S-3-B	400	0.00230	0.00085	0.00315	73.02
S-3-C	550	0.00102	0.00155	0.00257	39.69
MEAN (S-A)		0.00234	0.00112	0.00346	65.59
MEAN (S-B)		0.00178	0.00103	0.00281	63.05
MEAN (S-C)		0.00089	0.00144	0.00234	38.04

vapor-phase arsenic detected did not decrease proportionally to the increase in the amount of solid-phase arsenic detected as the filtered gas temperature was decreased from 288°C (550°F) to 121°C (250°F), the total amount of arsenic detected in the high temperature samples was uniformly less than the total amount detected in the low temperature samples.

The percentage of the arsenic detected in the solid phase at a filtered gas temperature of 121°C (250°F) ranged from a low of 48 percent to a high of about 82 percent. The validity of the S-1-A and S-2-A values is questionable, however, because of the tears identified in these filters. At a filtered gas temperature of 288°C (550°F), from about 36 to 40 percent of the total arsenic catch was collected in the front half of the sampling train as particulate arsenic. Once again, the validity of these results is questionable because the total amount of arsenic detected declined with increasing filtered gas temperature.

Because of the inconsistencies in the data, and because the measured concentrations of arsenic were so uniformly low, it is difficult to draw any general conclusions from the results of this test. The data did appear to indicate that a relationship exists between the temperature of the filtered gas and the amount of arsenic captured in the probe and filter (particulate arsenic). However, the data did not consistently indicate that the increase in the amount of particulate arsenic captured as the temperature of the filtered gas was cooled resulted from condensation of vapor-phase arsenic. Therefore, other explanations for the trends observed in the data cannot be completely discounted. For example, the collection efficiency of the entire sampling train may have been somehow impaired during these tests when the filtered gas was maintained at elevated temperatures.

A.1.3 Summary of EPA Method 108 Tests

Table A-2 gives the results obtained from the four EPA Method 108 tests on the soda-lime furnace. The amount of total arsenic detected in the solid-phase ranged from 66.9 percent to 83.6 percent. On the average, about 74 percent of total arsenic was captured in the front half of the sampling trains. This was considerably less than the percentage of solid-phase arsenic found in other tests. The other tests had indicated that more than

TABLE A-2. SUMMARY OF EPA METHOD 108 TESTS ON A SODA-LIME FURNACE

Run ID	Vapor (gr/dscf)	Arsenic Emissions Solid (gr/dscf)	Total (gr/dscf)	Solid (%)
P-1	0.00064	0.00249	0.00313	79.55
P-2	0.00105	0.00218	0.00323	67.49
P-3	0.00045	0.00230	0.00275	83.64
P-4	0.00116	0.00234	0.00350	66.86
MEAN	0.00083	0.00233	0.00315	74.38

90 percent of the arsenic emitted from glass melting furnaces is in the solid phase and collected by conventional particulate control devices.

A.2 SUMMARY OF EMISSION TESTING AT FOSTORIA GLASS COMPANY

A.2.1 Introduction

Emission tests were conducted at Fostoria Glass Company from October 11-13, 1983, and from November 1-3, 1983. During the October tests, arsenic was being added to the batch raw materials in the form of powdered arsenic trioxide. For the November tests, liquid arsenic acid was substituted. Both EPA Method 5 (particulate emissions) and EPA Method 108 (arsenic emissions) were employed. In addition, three single point samples were taken during both the October and November tests. During each single point run, two sampling trains were used simultaneously. The temperature of the filtered gas was maintained at 121°C (250°F) in one, and at 288°C (550°F) in the other. The objective of the single point tests was to test the effect that temperature has on the phase composition of the emitted arsenic.

Fostoria Glass Company produces a lead-crystal glass in a single melting furnace. Arsenic is added to the batch as a refining agent in the form of powdered arsenic trioxide under normal operating conditions. Emissions from the furnace are controlled by an electrostatic precipitator (ESP).

A.2.2 Summary of Single Point Tests

Table A-3 provides a summary of the results from the single point tests. Runs S-1, S-2, and S-3 were performed in October when arsenic trioxide was being used; runs S-4, S-5, and S-6 were conducted while arsenic acid was being used during November.

In each run, at both 121°C (250°F) and 288°C (550°F), over 99 percent of the arsenic collected was in the solid phase. The highest concentration of vapor-phase arsenic detected was 0.00023 gr/dscf in run S-3 at 121°C

TABLE A-3. SUMMARY OF SINGLE POINT TESTS AT FOSTORIA GLASS COMPANY

Run ID	Sample Temp (°F)	Arsenic Emissions Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Solid (%)
S-1 A	550	0.01890	0.00006	0.01896	99.67
S-1-B	250	0.02490	0.00004	0.02494	99.86
S-2-A	550	0.02580	0.00007	0.02587	99.72
S-2-B	250	0.02610	0.00008	0.02618	99.68
S-3-A	550	0.02090	0.00006	0.02096	99.72
S-3-B	250	0.02610	0.00023	0.02633	99.12
MEAN (S-A)		0.02187	0.00007	0.02193	99.70
MEAN (S-B)		0.02570	0.00012	0.02582	99.55
S-4-A	550	0.02620	0.00015	0.02635	99.43
S-4-B	250	0.02150	0.00010	0.02160	99.52
S-5-A	550	0.01930	0.00008	0.01938	99.59
S-5-B	250	0.01840	0.00007	0.01847	99.65
S-6-A	550	0.01510	0.00009	0.01519	99.39
S-6-B	250	0.01640	0.00007	0.01647	99.56
MEAN (S-A)		0.02020	0.00011	0.02031	99.47
MEAN (S-B)		0.01877	0.00008	0.01885	99.58

(250°F). This corresponds to 0.9 percent of the total arsenic detected in this run. On average, 99.6 percent of the total arsenic catch was in the particulates.

Little or no difference was apparent in the total amount of arsenic captured in the sampling train as a function of temperature. In runs S-1 and S-3 the total amount of arsenic detected was about 20 percent less at a filtered gas temperature of 288°C (550°F) than it was at 121°C (250°F). However, this difference is probably not significant given the small concentrations of arsenic present. Similarly, the data did not indicate that the temperature of the filtered gas had any significant effect on the proportion of arsenic captured in the particulate matter. In all runs, more than 99 percent of the arsenic was found in the solid phase regardless of temperature.

There was no significant difference between the overall results obtained when arsenic acid was used and when arsenic trioxide was used.

A.2.3 Summary EPA Method 108 Tests

Table A-4 summarizes the results of the EPA Method 108 tests. On average, 0.021 gr/dscf of arsenic were emitted from the furnace and about 0.00025 gr/dscf were finally emitted to the atmosphere.

The overall efficiency of the ESP in controlling emissions of arsenic ranged from 97.5 percent to 99 percent. An average efficiency of 98.7 percent was demonstrated. Control levels for solid-phase arsenic ranged from a low of 97.5 percent in run P-1, to a high of 99.2 percent in run P-4. The data also suggest that vapor-phase emissions were reduced across the control device. For example, in run P-2 vapor-phase emissions decreased by about 86 percent. However, because the outlet samples were collected at the stack rather than at the outlet duct from the control device, some condensation of arsenic could have occurred in the ducting or in the heat exchanger which immediately preceded the stack.

As in the results from the single point sampling, there were no indications that the form in which arsenic is added to the batch materials has any effect on either controlled or uncontrolled arsenic emissions.

TABLE A-4. SUMMARY OF ARSENIC EMISSIONS DATA FROM FOSTORIA GLASS COMPANY

	Uncontrolled Emissions			Controlled Emissions			Control
Run ID	Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Efficiency (%)
P-1	0.018	0.000010	0.0175	0.0004	0.000001	0.0004	97.50
P-2	0.022	0.000036	0.0224	0.0003	0.000005	0.0003	98.53
P-3	0.022	0.000054	0.0218	0.0002	0.000025	0.0002	98.95
MEAN	0.021	0.000033	0.0206	0.0003	0.000011	0.0003	98.33
P-4	0.017	0.000016	0.0165	0.0001	0.000004	0.0001	99.24
P-5	0.024	0.000068	0.0236	0.0003	0.000012	0.0003	98.88
P-6	0.024	0.000080	0.0245	0.0002	0.000015	0.0002	99.02
MEAN	0.021	0.000055	0.0215	0.0002	0.000010	0.0002	99.05

A.3. SUMMARY OF EMISSION TESTING AT INDIANA GLASS COMPANY

A.3.1 Introduction

Emission tests for inorganic arsenic were conducted at Indiana Glass Company over the period May 14 to 19, 1984. The furnace on which the tests were performed produces a crystal glass from a soda-lime recipe. Arsenic trioxide powder is added to the recipe to improve the clarity of the glass and to eliminate undesirable coloration. Emissions from the furnace are not controlled.

The purpose of the test was two-fold. One purpose was to gather further data on the proportion of arsenic emitted from soda-lime furnaces as particulate matter. As reported in Section A.1, an earlier test on a soda-lime furnace indicated that emissions from furnaces producing soda-lime glass might consist of relatively greater amounts of vapor-phase emissions compared to those from furnaces melting other types of glass. In addition, there were some indications from this test that cooling of the furnace exhaust gases might be effective in increasing the amount of arsenic emitted as particulate matter, and thereby increase the efficiency of conventional control devices in reducing arsenic emissions from soda-lime glass melting furnaces. However, the results from the previous test were difficult to interpret because some of the filters used during this test had torn while sampling was in progress.

The second purpose of the test was to determine the precision of the proposed EPA Reference Method 108 in measuring emissions of inorganic arsenic from glass melting furnaces. The precision of the method was estimated by calculating the relative standard deviations (the standard deviation expressed as a percentage of the mean value) of samples collected in a four-train (quad) sampling apparatus. This system allows four trains to sample simultaneously at essentially a single point in the stack which reduces the effect of variations in the velocity and particulate profiles on the sampling results. It also permits a statistically significant number of samples to be collected in a short amount of time. A total of nine quad train runs, representing 36 individual samples, were performed using EPA Method 108 sampling and analytical procedures.

The effect of temperature on the proportion of arsenic emitted as particulate matter was evaluated by maintaining the temperature of the filtered gas in the single-point quad sampling train at temperatures of 204°C (400°F) and 288°C (550°F). Altogether, four test runs were conducted at elevated sampling temperatures. In each run, the temperature of the filtered gas in two of the sampling trains was maintained at 204°C (400°F) and at 288°C (550°F) in the other two trains. During each run, a single Method 108 sampling train was operated at a filtered gas temperature of 121°C (250°F) for reference purposes. At the completion of the single-point sampling, three multi-point EPA Method 108 runs were conducted with a standard sampling train. The results of these tests are presented below.

A.3.2 Summary of Single Point Tests

The results of the single-point sampling at elevated filtered gas temperatures are given in Table A-5. During runs 11D, 12C, and 12D the filter supports ruptured as a result of thermal decomposition of the silica rubber gaskets. These ruptures allowed particulate matter to pass directly into the impingers. However, in run 12C the rupture occurred in the final minute of the 70 minute test run. Run 12D was terminated immediately after the rupture occurred. Sampling continued after the gasket failed in run 11D which invalidated the results from this run.

In every run, virtually all of the arsenic was emitted from the furnace as particulate matter. The temperature of the filtered gas had no effect on the proportion of arsenic captured as particulate. In each test run, less than 0.05 mg of arsenic was detected in the back-half of the sampling train. Because up to 0.05 mg of arsenic was detected in unused samples of the NaOH rinse and H_2O impinger solutions, after-sampling values of 0.05 mg or less are considered insignificant. Therefore, no significant amounts of arsenic were emitted from the Indiana Glass furnace in the vapor phase.

A.3.3 Summary of EPA Method 108 Tests

The results of the standard EPA Method 108 tests are presented in Table A-6. As was evident from the results of the single-point sampling, no significant amounts of vapor-phase arsenic were detected in the emissions. The total arsenic concentrations measured while traversing the stack were equivalent to the concentrations measured during single-point sampling.

TABLE A-5. SUMMARY OF SINGLE POINT TESTS AT INDIANA GLASS

			Arsenic Emissions		
Run ID	Sample Temp (°F)	Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Solid (%)
10A	400	0.00343	0.00001	0.00344	99.7
10B	400	0.00384	0.00001	0.00385	99.7
11A	400	0.00359	0.00001	0.00360	99.7
11B	400	0.00384	0.00002	0.00386	99.5
12A	400	0.00354	0.00000	0.00354	100.0
12B	400	0.00383	0.00001	0.00384	99.7
13A	400	0.00358	0.00001	0.00359	99.7
13B	400	0.00388	0.00001	0.00389	99.7
MEAN	400	0.00369	0.00001	0.00389	99.7
10C	550	0.00378	0.00001	0.00379	99.7
10D	550	0.00412	0.00001	0.00413	99.8
11C	550	0.00367	0.00000	0.00367	100.0
11D	550				
12C	550	0.00372	0.00000	0.00372	100.0
12D	550	0.00418	0.00001	0.00419	99.8
13C	550	0.00341	0.00002	0.00343	99.4
13D	550	0.00400	0.00002	0.00402	99.5
MEAN	550	0.00384	0.00001	0.00385	99.7
10-RT	250	0.00383	0.00000	0.00383	100.0
11-RT	250	0.00387	0.00001	0.00388	99.7
12-RT	250	0.00313	0.00000	0.00313	100.0
13-RT	250	0.00379	0.00002	0.00381	99.5
MEAN	250	0.00366	0.00001	0.00366	99.8

TABLE A-6. SUMMARY OF EPA METHOD 108 TESTS AT INDIANA GLASS

		Arsenic Emissions		
Run ID	Vapor (gr/dscf)	Solid (gr/dscf)	Total (gr/dscf)	Solid (%)
CD-1	0.00001	0.00374	0.00375	99.73
CD-2	0.00001	0.00359	0.00360	99.72
CD-3	0.00001	0.00324	0.00325	99.69
MEAN	0.00001	0.00352	0.00353	99.72

A.4 SUMMARY OF EMISSION TESTING AT CORNING GLASS WORKS IN MARTINSBURG, WEST VIRGINIA

A.4.1 Introduction

Emission tests for inorganic arsenic were conducted by EPA at Corning Glass Works in October 1984. The furnace on which the tests were performed produces a pyro-ceramic composition which is derived from an aluminosilicate batch recipe. Liquid arsenic acid (H_2AsO_4) is added to the recipe as a fining agent. Emissions from the furnace were not controlled.

The purpose of the test was two-fold. One purpose was to gather further data on the proportion of solid phase arsenic emitted from the aluminosilicate glass furnace. Previous tests conducted by Corning demonstrated that the proportion of arsenic emitted as particulate matter varied significantly from test to test and this variability was apparently independent of process parameters. The second purpose was to determine the effect of sampling train filter temperature on the collection of particulate arsenic.

The emission tests consisted of five separate single point runs using a four train (quad) sampling system, and a single standard EPA Method 108 sampling train. Single point testing consists of simultaneous operation of the four sampling trains at a single point in the offgas stream. During the tests, the temperature of the filters in two of the single point sampling trains was maintained at 204°C (400°F) and at 288°C (550°F) in the other two trains. In addition, each of the two higher temperature sampling trains (204°C and 288°C) had a back-up filter before the impingers. These back-up filters were maintained at 121°C (250°F).

A standard EPA Method 108 sampling train with a filter temperature of 121°C (250°F), was also operated during each of the test runs for reference purposes. Except for the third run, the standard reference tests and the single point tests were conducted simultaneously.

During the same period, tests were also conducted by Corning Glass Works on a pilot scale fabric filter system. The efficiency of the pilot system in controlling arsenic emissions at varying operating temperatures was determined.

A.4.2 Summary of EPA Method 108 Tests

Table A-7 summarizes the results of the EPA Method 108 tests. Total arsenic emissions ranged from 0.0325 to 0.0536 gr/dscf. On the average, 0.0436 gr/dscf of arsenic were emitted from the furnace. The proportion of solid phase arsenic ranged from 29 to 45 percent. On the average, the solid phase arsenic was approximately 39 percent.

A.4.3 Summary of EPA Single Point Tests

The results of the single-point sampling at elevated filtered gas temperatures are given in Table A-8. The percentage of the arsenic detected in the solid phase ranged from a low of 26 percent to a high of about 51 percent. Ten samples were collected at a filtered gas temperature of 204°C (400°F) and 9 samples were collected at 288°C (550°F). The average solid phase arsenic collection using the 204°C (400°F) sample trains was 34 percent, while the average of the 288°C (550°F) trains was 36 percent. This average was not statistically different from the average (39 percent) of the Method 108 reference train.

However, while this indicates no effect of temperature on the proportion of solid phase arsenic emitted from this furnace, substantial amounts of arsenic were collected in the back-up filters maintained at 121°C (250°F). As can be seen from Table A-9, the sampling trains with back-up filters show a significant degree of condensation of arsenic between the higher temperature filters and the 121°C filters. This discrepancy may result due to the fact that condensation may be occurring in the sampling train as a function of residence time in the sampling system, temperature gradient of the sampling train, and/or the probe location. Therefore, in instances where the concentration of vapor-phase arsenic is sufficiently high to be sensitive to condensation effects, the sampling train may not provide a reliable indication of the actual proportion of solid phase arsenic in the furnace exhaust or the effectiveness of a control device in reducing total arsenic emissions.

TABLE A-7. SUMMARY OF EPA METHOD 108 TESTS ON CORNING/MARTINSBURG ALUMINOSILICATE FURNACE

Run ID	Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Solid (%)
RT-1	0.01140	0.02108	0.03247	35.09
RT-2	0.01043	0.02609	0.03652	28.55
RT-3	0.02178	0.03181	0.05359	40.64
RT-4	0.02081	0.02587	0.04664	44.62
RT-5	0.02116	0.02737	0.04853	43.61
MEAN	0.01712	0.02644	0.04355	38.50

TABLE A-8. SUMMARY OF SINGLE POINT TESTS ON CORNING/MARTINSBURG ALUMINOSILICATE FURNACE

		Arsenic Emissions			
Run ID	Filter Temp (°F)	Solid (gr/dscf)	Vapor (gr/dscf)	Total (gr/dscf)	Solid (%)
S-1-A	361	0.01250	0.02719	0.03964	31.52
S-1-B	352	0.01571	0.03806	0.05377	29.21
S-1-C[a]	-	-	-	-	
S-1-D	511	0.01443	0.02358	0.03802	37.96
S-2-A	351	0.01632	0.01553	0.03190	51.17
S-2-B	349	0.01522	0.02825	0.04347	35.02
S-2-C	504	0.01500	0.02350	0.03850	38.97
S-2-D	518	0.01228	0.01492	0.02719	45.15
S-3-A	356	0.01456	0.03802	0.05258	27.70
S-3-B	352	0.01619	0.03934	0.05557	29.14
S-3-C	514	0.01390	0.03080	0.04074	34.13
S-3-D	527	0.01703	0.03159	0.04858	35.05
S-4-A	351	0.01967	0.02891	0.04853	40.53
S-4-B	347	0.01654	0.02948	0.04598	35.98
S-4-C	505	0.01654	0.02666	0.04321	38.29
S-4-D	518	0.01311	0.01958	0.03269	40.11
S-5-A	358	0.01518	0.03590	0.05108	29.72
S-5-B	356	0.01465	0.03560	0.05025	29.16
S-5-C	516	0.01241	0.03454	0.04695	26.43
S-5-D	527	0.01421	0.03287	0.04721	30.10
MEAN S-A	355	0.01565	0.02911	0.04475	36.13
MEAN S-B	351	0.01566	0.03415	0.04981	31.70
MEAN S-C	510	0.01446	0.02889	0.04235	34.46
MEAN S-D	520	0.01421	0.02451	0.03874	37.67

[a] Run S-1-C is void due to excessive post-test leak rate.

TABLE A-9. PERCENTAGE OF TOTAL ARSENIC COLLECTED ON FRONT HALF, GLASS CONNECTOR AND BACKUP FILTER AT CORNING/MARTINSBURG FURNACE

Run ID	Filter Temp (°F)	Solid (%)
S-1-A	361	75%
S-1-D	511	86%
S-2-A	351	88%
S-2-D	518	89%
S-3-A	356	91%
S-3-D	527	91%
S-4-A	351	94%
S-4-D	518	73%
S-5-A	358	95%
S-5-D	527	93%

A.4.4 Summary of Pilot Scale Fabric Filter Performance Tests

The purpose of the pilot test was to investigate the effect of offgas temperature and cooling techniques on the arsenic reduction performance of the pilot scale fabric filter system. Furnace offgases were tapped from the process stream prior to the main stack control damper. The hot exhaust gases at 272°C to 318°C (522 to 605°F) were cooled by a liquid spray tower or by air dilution prior to the fabric filter. Water and a mixture of sodium hydroxide and water were the liquids used during the spray tower cooling tests. Thermocouples located at the inlets and outlets of the spray tower and the fabric filter provided gas stream temperature measurements during the test runs. A total of 33 test runs were conducted by simultaneously collecting samples upstream and downstream of the pilot scale fabric filter system. All samples were collected using EPA Method 108 sampling procedures. Nine test runs were performed with baghouse inlet temperatures between 129°C and 139°C (265 and 283°F). These nine tests are referred to as high temperature runs. Twenty-four test runs were conducted with baghouse inlet temperatures ranging from 92 to 111°C (198 to 232°F) and these are referred to as low temperature runs.

The performance of the fabric filter was tested under 4 sets of conditions. These are (1) water cooling with high temperature baghouse, (2) water cooling with low temperature baghouse, (3) water and sodium hydroxide cooling with low temperature baghouse, and (4) cooling by air dilution with low temperature baghouse.

A.4.5 Summary of Fabric Filter Performance Data

The results of the pilot scale fabric filter performance tests also indicate that the stack gas sampling protocols may not provide a reliable indication of the proportion of arsenic emitted as particulate matter when this proportion is sensitive to gas stream temperature. Table A-10 shows the fraction of solid phase arsenic detected prior to the fabric filter. These data were collected with EPA Method 108 sampling trains (filter temperature of 121°C) and flue gas temperatures similar to those for EPA tests. An average of 77 percent of the arsenic was found to be in the solid

TABLE A-10. CORNING GLASS/MARTINSBURG PILOT PROJECT
SUMMARY OF UNCONTROLLED ARSENIC EMISSIONS DATA

		UNCONTROLLED EMISSIONS				
Run No.	Description	Solid Arsenic (gr/dscf)	Vapor Arsenic (gr/dscf)	Total Arsenic (gr/dscf)	Solid Arsenic (%)	Total Particulate (gr/dscf)
1-6	High Temp FF Inlet Water Cooling	0.043	0.009	0.052	83	0.073
7-12	Low Temp FF Inlet Water Cooling	0.049	0.007	0.056	88	0.094
13-15	Low Temp FF Inlet NaOH/Water Cooling	0.042	0.009	0.051	82	0.077
16-18	Low Temp FF Inlet Air Dilution	0.052	0.010	0.062	84	0.078
19-21	Low Temp FF Inlet Air Dilution	0.022	0.006	0.028	79	0.035
22-24	Low Temp FF Inlet Air Dilution	0.025	0.012	0.037	68	0.055
25-27	High Temp FF Inlet Water Cooling	0.017	0.010	0.027	63	0.041
28-30	Low Temp FF Inlet Water Cooling	0.022	0.009	0.031	71	0.048
31-33	Low Temp FF Inlet Air Dilution	0.026	0.004	0.030	87	N/A
MEAN		0.034	0.017	0.043	77	0.063

phase compared to only about 39 percent for the EPA reference Method 108 sampling trains and about 87.5 percent for the EPA single-point tests with back-up filters.

Table A-11 presents a summary of the fabric filter performance data. The initial six test runs were conducted while the temperature of the control device was maintained at a temperature of about 138°C (280°F). Control efficiencies for total arsenic during these runs ranged from about 58 percent to 82 percent, and averaged about 71 percent. Significantly higher removal efficiencies were obtained during the following 15 test runs (runs 7 through 21) after the operating temperature of the fabric filter was lowered to about 104°C (220°F). The control efficiencies for total arsenic emissions averaged about 90 percent during these 12 test runs. Although the efficiency of the control device decreased during the next three test runs, these were performed after the production rate of the furnace had been decreased by about 20 percent.

For test runs 25, 26, and 27, the operating temperature of the control device was increased to about 138°C (280°F). The data from these runs indicated that the average amount of arsenic exiting the fabric filters was only slightly less than the amount measured at the inlet. The increase in temperature may have caused the evaporation and subsequent entrainment of some of the arsenic previously collected in the filters.

The results obtained from the final six test runs (all at low temperatures) showed wide variability in arsenic removal efficiencies, possibly as a result of further declines in the production rate of the furnace.

Table A-12 shows the average control efficiencies achieved under various operating conditions of both the control device and the melting furnace. Significantly higher removal efficiencies were obtained when the temperature of the fabric filter was maintained below 121°C (250°F) regardless of furnace production rate or cooling method. In considering the data obtained at low control device temperatures only, the production rate of the furnace appeared to exert the greatest influence on arsenic removal efficiencies. During the tests conducted with water spray cooling, average

TABLE A-11. SUMMARY OF FABRIC FILTER PERFORMANCE TESTS CORNING/MARTINSBURG PILOT PROJECT

				Average Percent Reduction %		
Run No.	Description	Fabric Filter Temp °F	Particulate Arsenic (%)	Vapor Arsenic (%)	Total Arsenic (%)	Total Particulate
1-6	High Temp FF Inlet Water Cooling	276	79.7	27.6	70.5	80.8
7-12	Low Temp FF Inlet Water Cooling	215	95.2	66.5	92.5	93.9
13-15	Low Temp FF Inlet NaOH/Water Cooling	230	97.8	59.6	92.2	98.2
16-18	Low Temp FF Inlet Air Dilution	227	98.3	42.9	90.0	94.7
19-21	Low Temp FF Inlet Air Dilution	224	94.6	51.0	84.8	95.2
22-24	Low Temp FF Inlet Air Dilution	225	91.4	60.4	80.8	95.8
25-27	High Temp FF Inlet Water Cooling	283	-14.2	32.0	5.5	66.2
28-30	Low Temp FF Inlet Water Cooling	219	92.7	39.0	78.2	96.2
31-33	Low Temp FF Inlet Air Dilution	N/A	95.0	72.2	93.2	N/A

TABLE A-12. ARSENIC CONTROL EFFICIENCY OF CORNING/MARTINSBURG PILOT FABRIC FILTER UNDER VARIOUS TEST CONDITIONS

Fabric Filter Temperature	Furnace Production Rate	Method of Cooling	No. of Data Points	Average Arsenic Reduction (%)
High	High	Water Spray	4	70.5
High	All	Water Spray	7	42.6
Low	High	Water Spray	9	92.1
Low	Low	Water Spray	3	78.2
Low	All	Water Spray	12	88.6
Low	High	Air Dilution	6	87.4
Low	Low	Air Dilution	5	80.8
Low	All	Air Dilution	11	86.5

removal efficiencies of about 92 percent were achieved at high furnace production rates, compared to an average of about 78 percent at lower production rates. Similarly, when cooling was achieved by air dilution the average percent reduction obtained at high production rates was higher than those obtained at low production rates. As can be seen in the data provided in Table A-10, the concentration of particulate arsenic entering the control device decreased with decreasing production rate while the concentration of gaseous arsenic remained relatively constant. Therefore, at lower production rates proportionally less arsenic entered the control system in particulate form and was captured in the fabric filters. The concentration of total arsenic in the gas leaving the control device remained constant at all production rates. Cooling by air dilution also decreased the concentration of arsenic at the inlet of the control device, although it did not appear to affect significantly the proportion of particulate arsenic. As a result, the results obtained during cooling by dilution air are not significantly different from those obtained during water cooling.

A.5 SUMMARY OF EMISSIONS DATA SUPPLIED BY INDUSTRY REPRESENTATIVES

A.5.1 Introduction

In response to requests from EPA, industry representatives supplied additional data on arsenic emissions from glass melting furnaces. These data are summarized in the following sections. Because EPA was not present during these tests, and because in some cases the test methods employed do not fully conform to EPA reference test methods, the results of the tests cannot be fully evaluated.

For each test, the average temperature of the stack gas is given. However, the temperature of the filtered gas in the sampling train was maintained at about 121°C (250°F) in each of these tests. Therefore, arsenic present in the stack gas as vapor-phase arsenic might condense into particulate arsenic as the gas is cooled within the sampling train, and thereby obscure any relationship between stack gas temperature and the proportion of arsenic emitted as particulate matter.

A.5.2 Summary of Arsenic Emissions Testing on the Corning Soda-Lime Furnace in Charleroi, Pennsylvania

A soda-lime glass recipe is melted in a furnace located at Corning Glass Works' facility in Charleroi, PA. Emissions from the furnace are uncontrolled and exhausted to two separate stacks. Each stack has been tested five times for emissions of both solid- (probe and filter catch) and vapor-phase (impinger catch) arsenic. Prior to 1976, powdered arsenic trioxide was added to the batch. After 1976, the plant switched to liquid arsenic acid.

The results of these five tests are shown in Table A-13. In most tests, more than 99 percent of the emitted arsenic was found to be in particulate matter. However, in the April 1983 test only 50 to 60 percent of the arsenic emitted from the main stack was detected in the solid phase.

TABLE A-13. SUMMARY OF ARSENIC EMISSIONS TESTING ON CORNING/CHARLEROI SODA-LIME

	Main Stack				Auxiliary Stack				Total		
Date	Temperature[a] (°F)	Solid (lb/hr)	Vapor (lb/hr)	Solid (%)	Temperature[a] (°F)	Solid (lb/hr)	Vapor (lb/hr)	Solid (%)	Solid (lb/hr)	Vapor (lb/hr)	Solid (%)
03/16/84[b]	571	0.41	<0.01	>99	476	0.10	<0.01	>99	0.51	<0.02	>96
03/16/84[b]	574	0.42	<0.01	>99	485	0.10	<0.01	>99	0.52	<0.02	>96
03/17/84[b]	560	0.41	<0.01	>99	511	0.09	<0.01	>99	0.50	<0.02	>96
07/18/83[b]	639	0.67	0.03	96	552	0.20	0.03	87	0.87	0.06	93
07/18/83[b]	651	0.65	0.05	93	563	0.20	0.01	95	0.85	0.06	93
07/18/83[b]	637	0.52	0.13	80	600	0.47	0.01	98	0.99	0.14	86
04/23/83[b]	505	0.11	0.11	50	326	0.06	<0.01	>86	0.17	<0.12	>57
04/23/83[b]	502	0.11	0.07	61	300	0.06	<0.01	>86	0.17	<0.08	>68
06/03/74[c]	1055	0.68[d]	<0.01	>99	543	0.19[d]	<0.01	>99	0.87[d]	<0.02	>99
06/04/74[c]	1053	0.69[d]	<0.01	>99	531	0.20[d]	<0.01	>99	0.88[d]	<0.02	>99
06/05/74[c]	1096	0.67[d]	<0.01	>99	543	0.20[d]	<0.01	>99	0.86[d]	<0.02	>99
04/26/74[c]	937	0.42[d]	<0.01	>99	547	0.26[d]	<0.01	>99	0.68[d]	<0.02	>97
04/26/74[c]	931	0.54[d]	<0.01	>99	539	0.23[d]	<0.01	>99	0.77[d]	<0.02	>98
04/27/74[c]	935	0.49[d]	<0.01	>99	529	0.19[d]	<0.01	>99	0.68[d]	<0.02	>97

[a] Average temperature of stack gas
[b] Arsenic acid
[c] Arsenic trioxide
[d] Filter only; probe wash not analyzed for arsenic

During the same test, more than 86 percent of the arsenic in the auxiliary stack was emitted as particulate matter. In the test conducted in July, 1983, the proportion of arsenic collected as particulate matter ranged from 80 percent to 96 percent in the main stack, and from 87 to 98 percent in the auxiliary stack. No explanation could be found for the variations in the solid/vapor split during tests conducted at different times.

A.5.3 Summary of Arsenic Emission Testing on the Corning Aluminosilicate Furnace in Charleroi, Pennsylvania

The results of an emissions test on Corning's aluminosilicate glass melting furnace in Charleroi, PA are given in Table A-14. This furnace is also equipped with two separate stacks. Liquid arsenic acid is used as a raw material in this furnace. Arsenic emissions from the main stack were sampled on April 21, 1983; the auxiliary stack was tested the following day. Tests on the main stack showed that 95 percent of the arsenic is emitted in the solid phase. A somewhat smaller fraction (about 90 percent) of the total arsenic was found in the solid phase in the emission from the auxiliary stack.

A.5.4 Summary of Arsenic Emission Testing on the Corning Aluminosilicate Furnace in Martinsburg, West Virginia

An aluminosilicate glass composition is produced in the Corning/Martinsburg furnace and arsenic is added to the batch raw materials as a liquid acid. This furnace has been tested numerous times since 1978 for emissions of arsenic. Table A-15 summarizes the results of these tests. The fraction of arsenic captured in the particulate matter ranges from a low of 29 percent to a high of nearly 100 percent. Significant variability is apparent even for tests performed on the same day. During the test performed on November 4, 1982, the proportion of arsenic captured as particulate matter ranged from less than 30 percent to more than 60 percent. Similar variability is apparent in the data obtained from the test on November 30, 1983. Additional data supplied by Corning (docket entry A-83-08, IV-D-28) show that the fraction of arsenic emitted in the solid phase did not correlate to the production rate of the furnace or the amount of cullet added to the fresh raw materials.

TABLE A-14. SUMMARY OF ARSENIC EMISSIONS TESTING ON CORNING/CHARLEROI ALUMINOSILICATE FURNACE

Date	Temperature[a] (°F)	Solid (lb/hr)	Vapor (lb/hr)	Total (lb/hr)	Solid (%)
4/21/83[b]	698	0.82	0.04	0.86	95
4/21/83[b]	699	0.88	0.05	0.93	95
4/22/83[c]	791	0.67	0.08	0.75	89
4/22/83[c]	800	0.80	0.09	0.89	90

[a] Temperature of stack gas
[b] Main stack
[c] Auxiliary stack

TABLE A-15. SUMMARY OF ARSENIC EMISSIONS TESTING ON CORNING/MARTINSBURG ALUMINOSILICATE FURNACE

Date	Temperature[a] (°F)	Solid (lb/hr)	Vapor (lb/hr)	Total (lb/hr)	Solid (%)
05/08/78	570	10.40	0.19	10.59	98
05/08/78	560	10.90	0.02	10.92	100
05/09/78	500	9.60	0.27	9.87	97
05/11/78	814	6.57	1.10	7.67	86
05/11/78	824	8.33	1.30	9.63	87
05/15/78	820	7.74	1.30	9.04	86
05/16/78	817	8.23	1.20	9.43	87
06/12/78	748	4.18	1.80	5.98	70
06/29/78	722	2.43	1.50	3.93	62
11/04/82	598	1.15	2.88	4.03	29
11/04/82	592	1.09	2.06	3.15	35
11/04/82	594	2.23	1.41	3.64	61
11/30/82	562	1.14	0.80	1.94	59
11/30/82	557	0.91	1.70	2.61	35
11/30/82	560	1.17	1.29	2.46	48
03/29/83	569	1.95	0.58	2.53	77
03/29/83	559	1.95	0.33	2.28	86
05/06/83	559	2.43	0.76	3.19	76
05/06/83	607	4.12	0.56	4.68	88
05/06/83	608	4.19	0.54	4.73	89
05/24/83	613	4.85	0.86	5.71	85
05/24/83	630	4.58	0.55	5.13	89
05/24/83	614	2.92	0.44	3.36	87
MEAN	635	4.48	1.02	5.50	75

[a] Temperature of stack gas

A.5.5 Summary of Data Provided by Owens-Illinois, Inc.

Emissions from four furnaces located at two different Owens-Illinois plants have been tested for arsenic. All of these furnaces produce a soda-lime glass. The results of these tests are summarized in Table A-16. In four of the eight tests, no arsenic was detected in the vapor phase. In one test, trace amounts of vapor-phase arsenic were detected, but were too small to be quantified. However, in two other tests, significant amounts of vapor-phase arsenic were found. The second test run on the Shreveport "C" furnace indicated that only about 78 percent of the arsenic was emitted as particulate matter. In the second test run on the Shreveport "A" furnace, about 85 percent of the emitted arsenic was found in the particulate matter.

TABLE A-16. SUMMARY OF ARSENIC EMISSIONS TESTING ON OWENS-ILLINOIS SODA-LIME FURNACES

Date	Temperature[a] (°F)	Solid (lb/hr)	Vapor (lb/hr)	Total (lb/hr)	Solid (%)
06/27/83[b]	570	0.15	ND[c]	0.15	100
06/27/83[b]	560	0.22	0.06	0.29	78
06/29/83[d]	500	0.08	Trace	0.08	<100
06/30/83[d]	490	0.25	0.04	0.29	85
08/02/83[e]	640	0.05	ND[c]	0.05	100
08/03/83[e]	630	0.06	ND[c]	0.06	100
08/05/83[f]	480	0.02	ND[c]	0.02	100
08/05/83[f]	470	0.02	ND[c]	0.02	100

[a] Temperature of stack gas
[b] Shreveport furnace "C"
[c] None detected
[d] Shreveport furnace "A"
[e] Toledo furnace "G"
[f] Toledo furnace "D"

APPENDIX B

UPDATED COST AND ECONOMIC ANALYSIS

B.1 INTRODUCTION

In the Background Information Document (BID) for the proposed NESHAP for the glass industry, the costs and the economic impacts associated with the proposed standard were analyzed. Although at the time of proposal information was available on the financial characteristics of affected glass companies, sufficient data were not available to estimate the cost impacts of controlling all arsenic-using glass furnaces operated by those companies. There was also some uncertainty as to whether all arsenic-using furnaces had been identified. Therefore, the capital and annualized costs of arsenic emissions control were estimated for six model glass melting furnaces (Chapter 6). Based on these cost estimates, the economic impact on potentially affected glass companies was evaluated (Chapter 7).

In order to more accurately evaluate the economic impacts associated with this NESHAP, detailed information was gathered after proposal on potentially affected furnaces and the plants at which those furnaces are located. This information enabled the costs associated with alternative control options to be estimated for specific furnaces and specific plants. On the basis of the updated cost analysis, the economic impacts of alternative control options were reassessed.

This Appendix provides updated information on the costs and economic impacts which were considered in establishing the promulgated standard. In the following section, the changes made after proposal in the methodology for estimating costs and economic impacts are reviewed. Section B.3 summarizes the results of the updated cost analysis, and section B.4 reports the results of the updated economic analysis.

B.2 CHANGES IN COST AND ECONOMIC ANALYSIS SINCE PROPOSAL

B.2.1 Changes in Cost Analysis

The capital and annualized costs associated with controlling emissions of arsenic from glass melting furnaces are a function of the exhaust gas flow rate through the control device and the level of control required. At proposal, the costs of reducing total particulates to the levels specified in the proposed NESHAP for glass manufacturing plants were estimated on the basis of exhaust gas flow rates for model plants. However, the cost estimates for the promulgated standard are based on actual flow rates at existing furnaces. The required level of control is assumed to be a reduction in particulate arsenic emissions of at least 92 percent for soda-lime glass and at least 95 percent for other types of glass. On the basis of data provided in the BID for the NSPS for glass manufacturing plants, the specific collection areas (SCA) of ESPs necessary to achieve these percent reductions were determined. For soda-lime glass, an SCA of 400 ft^2/1,000 acfm was determined to be necessary to achieve a reduction in particulate arsenic emissions of at least 92 percent. For other types of glass, an SCA of 1,000 ft^2/1,000 acfm would be required to achieve a 95 percent reduction in particulate arsenic emissions.

Because the exhaust gas flow rate is dependent on numerous site-specific factors including the capacity of the furnace, the type and amount of fuel used, the type of glass produced, the temperature of the exhaust gases, and other furnace operating parameters, actual flow rates were obtained for all arsenic-using furnaces emitting more than 0.4 Mg (0.44 ton) of arsenic per year. The actual flows were corrected to reflect a control device temperature of 400°F and then multiplied by the required SCA to determine the total plate area necessary to achieve the assumed control level. Capital and annualized costs were then estimated on the basis of the required plate area for actual furnaces using the same cost algorithms presented in Chapter 6 of the proposal BID.

In the cost analysis performed prior to proposal, it was assumed that a separate control device would be installed on each affected furnace. However, the costs of ESPs and fabric filters do not increase proportionally with increasing collection area. Therefore, at plants with multiple furnaces in close proximity to one another, a single control device would likely be installed to control emissions from multiple furnaces. The locations of individual furnaces within potentially affected glass manufacturing plants were evaluated with respect to the feasibility of controlling multiple furnaces with a single control device. In cases where it was determined technically feasible to do so, the costs of controlling multiple furnaces with a single control device were estimated.

B.2.2 Changes in Economic Analysis

One objective of the economic analysis is to estimate the increase in production costs that would be incurred in controlling emissions of arsenic from glass melting furnaces. The increase in production costs can then be used to estimate either the decline in profits (cost absorption) or increases in prices (cost pass-through) that would occur as a result. At the time of proposal, no data were available on the actual costs of producing specific types of glass within the pressed and blown segment of the glass industry. Instead, production costs were estimated on the basis of producer price indexes for various product categories. However, the producer price indexes related costs of production to the quantity of products shipped rather than to the weight of the products shipped. As a result, rough estimates were made of the specific production costs (i.e. $/unit weight of product) for various product types. In order to gain a more accurate perspective on the increases in production costs associated with a NESHAP for arsenic-using glass furnaces, individual companies were contacted for information on their current production costs for specific arsenic-containing glasses. This information was used in the updated economic analysis.

The previous analysis was also based on the assumption that all of the glass melted in a furnace was formed into a marketable product. In reality, however, a percentage of the glass produced does not meet quality specifications and is discarded as cullet. In the updated economic analysis, it is assumed that 70 percent of furnace production is actually sold as a final product. The 70 percent value was selected on the basis of typical cullet ratios for glass melting furnaces which average about 30 percent.

In the previous economic analysis, both impacts on price and profit were estimated. However, in reviewing the overall economic climate of the pressed and blown segment of the glass industry, it was determined that cost absorption (profit reduction) would be more likely for all types of products. Therefore, only impacts on profit were calculated in the updated economic analysis and profit ratios of indivuidual companies were applied to furnaces of these companies.

Finally, the updated economic analysis is based on the estimated costs of controlling specific furnaces rather than model furnaces. Accordingly, profit impacts were calculated for specific furnaces with known production rates of arsenic-containing glasses. The estimated decline in profit from an individual furnace provides an indication of the probability that a furnace would be shut down rather than equipped with a control device.

B.3 RESULTS OF UPDATED COST ANALYSIS

B.3.1 Number of Furnaces Considered

Control costs were estimated for the 11 uncontrolled furnaces that currently emit more than 0.4 Mg (0.44 ton) of arsenic per year. In addition, control costs were estimated for 13 uncontrolled furnaces which individually emit less than 0.4 Mg/year (0.44 ton/year), but are either located at the same plants as the higher emitting furnaces or at plants with relatively high total plant-wide emissions of arsenic. These 24 total furnaces are located at 6 separate glass manufacturing plants and have combined arsenic emissions of about 28.8 Mg/year (31.7 tons/year).

B.3.2 Estimated Control Costs

The estimated capital and annual costs of controlling each of the 24 arsenic-using glass furnaces are given in Table B-1. Only costs for ESPs

TABLE B-1. RESULTS OF COST ANALYSIS FOR UNCONTROLLED GLASS FURNACES

Plant Code	Furnace Code	Glass Type	Control Device Flowrate[a] (acfm)	Estimated Plate Area[b] (ft^2)	ESP Capital Cost ($)	ESP Annual Cost ($/year)
1	A	Soda-lime	18,081	7,232	1,342,100	268,000
	B	Soda-lime	17,727	7,091	1,328,100	265,100
	C	Soda-lime	33,939	13,576	1,873,800	376,500
1	A,B,C	Soda-lime	69,747	27,899	2,746,300	555,800
2	A	Soda-lime	7,842	3,137	862,000	170,700
	B	Soda-lime	9,124	3,650	933,900	185,200
	C	Soda-lime	6,086	2,434	753,700	148,900
	D	Soda-lime	12,965	5,186	1,125,200	223,900
	E	Soda-lime	14,557	5,823	1,196,500	238,400
	F	Soda-lime	17,899	7,160	1,335,000	266,500
	G	Soda-lime	15,960	6,384	1,256,200	250,500
	H	Soda-lime	6,103	2,441	754,700	149,100
	I	Soda-lime	10,125	4,050	987,000	195,900
2	A,B,C,D,E	Soda-lime	50,574	20,230	2,352,500	474,700
2	F,G,H,I	Soda-lime	50,087	20,035	2,297,900	463,500
3	A	Al-Silicate	25,800	25,800	2,633,500	532,500
4	A	Al-Silicate	25,696	25,696	2,627,800	531,400
5	A	Al-Silicate	18,993	18,993	2,238,800	451,300
6	A	Soda-lime	12,961	5,184	1,125,000	223,900
	B	Soda-lime	10,296	4,118	995,800	197,700
	C	Soda-lime	10,296	4,118	995,800	197,700
	D	Soda-lime	8,842	3,537	918,600	182,100
	E	Soda-lime	7,025	2,810	813,200	160,800
	F	Soda-lime	7,994	3,198	870,900	172,500
	G	Soda-lime	6,904	2,762	805,800	159,300
	H	Soda-lime	6,420	2,568	775,300	153,200
	I	Soda-lime	6,420	2,568	775,300	153,200
6	A,B,C,D	Soda-lime	42,395	16,958	2,108,300	424,600

a) At a temperature of 400°F.

b) Assumes a specific collection area of 400 ft^2/1,000 acfm for soda-lime glass and 1000 ft^2/1,000 acfm for other glass types.

were calculated. Except for the very smallest furnace sizes, the capital and annualized costs for EPSs are somewhat greater than those for fabric filter systems.

As mentioned above, the costs assume that furnaces producing soda-lime glass are required to reduce particulate arsenic emissions by 92 percent, and that furnaces producing other types of glass are required to reduce particulate arsenic emissions by 95 percent. At plants where it would be technically feasible to do so, the costs of installing a single device to control emissions from multiple furnaces have been estimated in addition to the costs of controlling the furnaces individually. The costs of combined control systems are, in all instances, lower than the costs for controlling each furnace separately. For example, the annual cost of controlling the three furnaces at plant 1 would be about $556,000 if a single control device were installed, compared to a total annual cost of about $910,000 for controlling these furnaces separately.

B.4 RESULTS OF UPDATED ECONOMIC ANALYSIS

Since the arsenic NESHAP for glass manufacturing plants was proposed on July 20, 1983, additional information has been collected on companies that operate arsenic-using furnaces. Therefore, the purpose of this section is to supplement the analysis of economic impact that was presented in the BID for the proposed standard.

Currently, three companies operate six plants having furnaces with potential arsenic emissions of more than 0.4 Mg (0.44 ton) per year. Twenty-four arsenic-using furnaces are located at these six plants. The three companies are Corning Glass Works, Owens-Illinois, Inc., and Lancaster

Colony Corporation. Background financial data for Corning Glass Works and Owens-Illinois, Inc. are presented in Tables 7-10 and 7-14, respectively, of the proposal BID and are not repeated here. Background financial data for Lancaster Colony Corp. are given in Table B-2.

B.4.1 Maximum Percent Profit Reductions

Estimated maximum profit impacts are based on the assumption that companies would be unable to increase their prices for products to cover the costs of installing and operating an emissions control device. If product prices are not increased and net sales remain constant, profits before taxes will be reduced. Therefore, the assumption of complete cost absorption presents a "worst case" from the standpoint of glass manufacturing companies.

The extent to which profit would be reduced can be estimated by comparing the baseline (i.e. before control) return on sales to the return on sales after emissions controls are installed. Return on sales is defined as profit before tax divided by total revenue (profit ratio). Before tax return on sales is used instead of after tax return on sales to avoid the complication of varying tax rates.

Financial data for glass companies are generally reported according to major segments of the business. For the glass industry, these business segments generally correspond to broad categories of products. However, within any overall product category, for example machine-made consumer glassware, a wide range of different individual products may be included. Therefore, profit ratios derived from financial data for these broad business segments may not precisely indicate the margin of profit on a

TABLE B-2. FINANCIAL CHARACTERISTICS OF LANCASTER COLONY CORPORATION[1] ($$10^6$)

Year	Company Total	Machine-made Consumer Glassware
	Sales	
1979	267.5	95.6
1980	291.1	111.2
1981	307.7	115.9
	Profits Before Taxes	
1979	20.6	9.1
1980	12.9	8.1
1981	19.6	11.1
	Assets	
1979	174.6	60.9
1980	172.1	65.3
1981	182.1	65.5
	Return on Sales (Percent)	
1979	7.7	9.5
1980	4.4	7.3
1981	6.4	9.6
Average	6.2	8.8
	Before Tax Return on Investment (Percent)	
1979	11.8	14.9
1980	7.5	12.4
1981	10.8	16.9
Average	10.0	14.7
	Sales to Assets (Ratio)	
1979	1.53	1.57
1980	1.69	1.70
1981	1.69	1.77
Average	1.63	1.68

particular arsenic-containing glass produced in a particular furnace. Nonetheless, more disaggregated data on before tax profits and total revenues are not publicly available, and the available data are considered sufficient for purposes of this analysis.

The ratios of before tax profits to sales used to estimate profit declines are shown in Table B-3. These ratios were derived from the financial data provided in Tables 7-10 to 7-17 of the proposal BID as well as from the financial data for Lancaster Colony Corporation shown in Table B-2. With the exception of machine-made consumer ware, the ratios reflect unweighted industry-wide averages for each product category (business segment). For furnaces producing machine-made consumer ware, individual company-wide profit ratios were used.

Table B-4 summarizes the profit declines estimated for the 24 glass melting furnaces under consideration. For each range of decline in profit, the number of furnaces within that range are shown, both when it is assumed that each individual furnace is controlled separately and when it is assumed that multiple furnaces are controlled by a centralized emissions control device. Assuming that all furnaces are individually controlled, profits from 21 of the 24 furnaces would decline by 15 percent or more. This range of profit decline is considered significant. Profit declines for 2 furnaces would be moderate, in the range of 5 to 15 percent, and applying controls to one furnace would have an insignificant impact of profit. However, when the more realistic situation is considered in which single control devices are applied, wherever feasible, to multiple furnaces, the overall impact on profit would be moderate for most furnaces. In this case, significant impacts on profit are estimated for 7 of the 24 furnaces.

TABLE B-3. SUMMARY OF FINANCIAL RATIOS FOR PROFIT IMPACTS

Product	Before Tax Profits to Sales[a] (Percent)
Machine-made tableware	7.5 to 8.3
T.V. envelope tubes	11.7

[a] The financial ratios are for the business segments in the firms producing that product

TABLE B-4. SUMMARY OF PROFIT IMPACTS

Range of Maximum Profit Declines (Percent)	Number of Furnaces (Separate Control)	Number of Furnaces (Multiple Control)
0-5	1	1
5-15	2	16
15-30	10	1
30-50	6	1
50+	5	5
TOTAL	24	24

The estimated impacts on profit for individual furnaces are given in Table B-5.

B.4.2 Capital Availability

The ability of the companies to finance the capital costs of emissions control devices must also be considered. The ratio of long-term debt to total capitalization (long term debt plus equity) provides a measure of capital availability. A high ratio (expressed as a percentage) generally indicates that additional debt financing may not be possible.

Table B-6 provides data on the ratio of long-term debt to total capitalization for the three firms considered. Data are presented for a period of four years in order to identify any trends in company debt ratios. The ratios of long-term debt to total capitalization for Owens-Illinois, Inc. and Lancaster Colony Corporation are more than double that for Corning Glass Works. All three firms show relatively stable debt ratios.

For purposes of this analysis, it was assumed that the costs of installing emission controls are financed solely through debt. The impact on capital availability of installing emissions control devices on arsenic-using furnaces can be measured by comparing the debt ratio prior to control to the debt ratio after control for each affected company. These ratios are shown in Table B-7, along with the percent increase in debt ratio resulting from installation of emissions control devices. Capital availability does not appear to be a major constraint. The highest estimated percent increase in debt ratio is for Lancaster Colony Corporation which increases by about 10 percent. However, for all three companies the ratio of long-term debt to total capitalization after controls is within the range of debt ratios experienced by these firms over the past four years.

TABLE B-5. ESTIMATED PROFIT DECLINES FOR INDIVIDUAL FURNACES

Plant	Furnace	Glass Type	Estimated ESP Capital Cost ($)	Total Estimated Annual Cost ($)	Product Category	Glass Price ($/lb)	Range of Profit Decline
1	A	S. Lime	1,342,100	268,000	Tableware	0.367	5%-15%
	B	S. Lime	1,328,100	265,100	Tableware	0.367	5%-15%
	C	S. Lime	1,873,800	376,500	Tableware	0.367	15%-30%
1	A,B,C	S. Lime	2,746,300	555,800	Tableware	0.367	5%-15%
2	A	S. Lime	862,000	170,700	Tableware	0.367	15%-30%
	B	S. Lime	933,900	185,200	Tableware	0.367	15%-30%
	C	S. Lime	753,700	148,900	Tableware	0.367	30%-50%
	D	S. Lime	1,125,200	223,900	Tableware	0.367	30%-50%
	E	S. Lime	1,196,500	238,400	Tableware	0.367	30%-50%
	F	S. Lime	1,335,000	266,500	Tableware	0.367	15%-30%
	G	S. Lime	1,256,200	250,500	Tableware	0.367	15%-30%
	H	S. Lime	754,700	149,100	Tableware	0.367	15%-30%
	I	S. Lime	987,000	195,900	Tableware	0.367	30%-50%
2	A,B,C,D,E	S. Lime	2,352,500	474,700	Tableware	0.367	5%-15%
2	F,G,H,I	S. Lime	2,297,900	463,500	Tableware	0.367	5%-15%
3	A	Al-Silicate	2,633,500	532,500	Tableware	1.99	<5%
4	A	Al-Silicate	2,627,800	531,400	Tableware	1.99	30%-50%
5	A	Sl-Silicate	2,238,800	451,300	Scientific Glass	0.726	15%-30%

TABLE B-5. ESTIMATED PROFIT DECLINES FOR INDIVIDUAL FURNACES (CONTINUED)

Plant	Furnace	Glass Type	Estimated ESP Capital Cost ($)	Total Estimated Annual Cost ($)	Product Category	Glass Price ($/lb)	Range of Profit Decline
6	A	S. Lime	1,125,000	223,900	Tableware	0.367	15%-30%
	B	S. Lime	995,800	197,700	Tableware	0.367	15%-30%
	C	S. Lime	995,800	197,700	Tableware	0.367	15%-30%
	D	S. Lime	918,600	182,100	Tableware	0.367	30%-50%
	E	S. Lime	813,200	160,800	Tableware	0.367	>100%
	F	S. Lime	870,900	172,500	Tableware	0.367	>100%
	G	S. Lime	805,800	159,300	Tableware	0.367	>100%
	H	S. Lime	775,300	153,200	Tableware	0.367	>100%
	I	S. Lime	775,300	153,200	Tableware	0.367	>100%
6	A,B,C,D	S. Lime	2,108,300	424,600	Tableware	0.367	5%-15%

TABLE B-6. RATIO OF LONG-TERM DEBT TO TOTAL CAPITALIZATION (PRE-CONTROL)[2]

	Corning Glass	Owens-Illinois	Lancaster Colony
		Long-Term Debt ($ 10^6)	
1978	163.4	691.	31.4
1979	147.1	697.	37.1
1980	153.6	687.	44.0
1981	200.1	618.	40.9
Average	166.0	673.3	38.4
		Total Capitalization (Long-Term Debt Plus Equity)	
1978	905.1	1,797.	93.8
1979	975.1	1,898.	106.1
1980	1,066.3	2,003.	116.8
1981	1,165.5	2,033.	122.3
Average	1,028.0	1,932.8	109.7
		Ratio of Long-Term Debt to Total Capitalization (Percent)	
1978	18.1	38.5	33.5
1979	15.1	36.7	35.0
1980	14.4	34.3	37.7
1981	17.2	30.4	33.4
Average	16.2	34.8	34.9

TABLE B-7. RATIO OF LONG-TERM DEBT TO TOTAL CAPITALIZATION (POST CONTROL)

Company	Ratio of Long-Term Debt to Total Capitalization Before Controls	After Controls	Percent Change
Corning Glass	16.2	16.8	3.7
Lancaster Colony	34.9	38.4	10.0
Owens-Illinois	34.8	35.1	0.9

B.4.3 Regulatory Flexibility

The Regulatory Flexibility Act (RFA) of 1980 requires that differential impacts of Federal regulations upon small business be identified and analyzed. The RFA stipulates that an analysis is required if a substantial number of small businesses will experience significant impacts. Both requirements, substantial numbers of small businesses and significant impacts, must to met to require an analysis. If either measure is not met, then no analysis is required.

The Small Business Administration (SBA) definition of small business for SIC 3229 is a company that employs 750 persons or fewer. Table B-8 shows recent employment levels for the three firms that will potentially be affected by this regulation. All of the firms have more than 750 employees. Therefore, none of the firms meets the SBA definition of small business and no regulatory flexibility analysis is required.

TABLE B-8. EMPLOYMENT IN AFFECTED COMPANIES, 1981[3-6]

Company	Employment
Corning Glass	30,200
Lancaster Colony	5,900
Owens-Illinois	51,000

APPENDIX C

AVAILABLE INORGANIC ARSENIC EMISSIONS DATA FOR EXISTING ARSENIC-USING GLASS PLANTS

Plant	Furnace	Glass Type	Existing Control Device Type[a]	Baseline Arsenic Emissions			
				(kg/hr)	(lb/hr)	(Mg/yr)	(ton/yr)
1	A	Soda-Lime	None	0.089	0.196	0.75	0.82
	B	Soda-Lime	None	0.095	0.209	0.80	0.88
	C	Soda-Lime	None	0.102	0.225	0.86	0.95
2	A	Soda-Lime	None	0.048	0.105	0.40	0.44
3	A	Lead	ESP	0.023	0.050	0.19	0.21
	B	Lead					
4	A	Soda-Lime	None	0.024	0.052	0.20	0.22
	B	Soda-Lime	None	0.024	0.052	0.20	0.22
	C	Soda-Lime	None	0.024	0.052	0.20	0.22
	D	Soda-Lime	None	0.010	0.023	0.09	0.10
	E	Soda-Lime	None	0.009	0.021	0.08	0.09
	F	Soda-Lime	None	0.033	0.073	0.28	0.31
	G	Soda-Lime	None	0.026	0.058	0.22	0.24
	H	Soda-Lime	None	0.024	0.052	0.22	0.22
	I	Soda-Lime	None	0.024	0.052	0.22	
5	A	Strontium	ESP	0.003	0.007	0.03	0.03
	B	Lead	ESP	0.001	0.002	0.01	0.01
6	A	Lead	ESP	0.010	0.021	0.08	0.09
7	A	Lead	ESP	0.005	0.010	0.04	0.04
8	A	Aluminosilicate	None	1.581	3.486	13.28	14.64
9	A	Aluminosilicate	None	0.390	0.860	3.41	3.75
	C	Fluoride/Opal	MC/ESP	0.001	0.003	0.01	0.01
10	A	Various	ESP				
	B	Various	ESP	0.006	0.013	0.05	0.06
	C	Various	ESP				
	D	Lead	ESP	0.008	0.018	0.07	0.08
	E	Lead	ESP				
11	A	Aluminosilicate	None	0.095	0.209	0.80	0.88
	B	Lead	FF	0.005	0.010	0.04	0.04

Plant	Furnace	Glass Type	Existing Control Device Type[a]	Baseline Arsenic Emissions			
				(kg/hr)	(lb/hr)	(Mg/yr)	(ton/yr)
12	A	Lead	ESP	0.002	0.005	0.02	0.02
13	A	Lead	ESP	0.023	0.050	0.19	0.21
14	A	Borosilicate	FF	0.023	0.050	0.19	0.21
15	A	Soda-Lime	None	0.269	0.593	2.26	2.49
	B	Soda-Lime	None	0.162	0.357	1.36	1.50
	C	Soda-Lime	None	0.162	0.357	1.36	1.50
	D	Soda-Lime	None	0.113	0.249	0.95	1.05
	E	Soda-Lime	None	0.046	0.102	0.39	0.43
	F	Soda-Lime	None	0.107	0.232	0.90	0.99
	G	Soda-Lime	None	0.040	0.089	0.34	0.37
	H	Soda-Lime	None	0.006	0.013	0.05	0.06
	I	Soda-Lime	None	0.006	0.013	0.05	0.06
16	A	Soda-Lime	None	0.048	0.105	0.40	0.44
	B	Soda-Lime	None	0.048	0.105	0.40	0.44
	C	Soda-Lime	None	0.048	0.105	0.40	0.44
	D	Soda-Lime	None	0.048	0.105	0.40	0.44
17	A	Soda-Lime	None	0.000	0.000	0.00	0.00
18	A	Soda-Lime	None	0.008	0.018	0.07	0.08
	B	Soda-Lime	None	0.008	0.018	0.07	0.08
19	A	Soda-Lime	None	0.000	0.001	0.00	0.00
	B	Soda-Lime	None	0.000	0.001	0.00	0.00
20	A	Soda-Lime	None	0.006	0.014	0.05	0.06
21	A	Soda-Lime	None	0.019	0.042	0.16	0.18
22	A	Soda-Lime	None	0.011	0.024	0.09	0.10
	B	Soda-Lime	None	0.011	0.024	0.09	0.10
	C	Soda-Lime	None	0.011	0.024	0.09	0.10
23	A	Soda-Lime	None	0.002	0.004	0.01	0.01
	B	Soda-Lime	None	0.002	0.004	0.01	0.01

Plant	Furnace	Glass Type	Existing Control Device Type[a]	Baseline Arsenic Emissions (kg/hr)	(lb/hr)	(Mg/yr)	(ton/yr)
24	A	Soda-Lime	None	0.003	0.007	0.03	0.03
	B	Soda-Lime	None	0.003	0.007	0.03	0.03
	C	Soda-Lime	None	0.003	0.007	0.03	0.03
	D	Soda-Lime	None	0.003	0.007	0.03	0.03
	E	Soda-Lime	None	0.003	0.007	0.03	0.03
	F	Soda-Lime	None	0.003	0.007	0.03	0.03
25	A	Soda-Lime	None	0.002	0.005	0.02	0.02
	B	Soda-Lime	None	0.002	0.005	0.02	0.02
	C	Soda-Lime	None	0.002	0.005	0.02	0.02
	D	Soda-Lime	None	0.002	0.005	0.02	0.02
26	A	Soda-Lime	None	0.000	0.000	0.00	0.00
	B	Soda-Lime	None	0.000	0.000	0.00	0.00
	C	Soda-Lime	None	0.000	0.000	0.00	0.00
	D	Soda-Lime	None	0.000	0.000	0.00	0.00
	E	Soda-Lime	None	0.000	0.000	0.00	0.00
27	A	Various	None	0.018	0.039	0.15	0.17
	B	Various	None	0.018	0.039	0.15	0.17
	C	Various	None	0.018	0.039	0.15	0.17
TOTAL				3.828	8.438	32.15	35.44

[a] ESP = Electrostatic Precipitator; MC = Multiple Cyclons; FF = Fabric Filter

APPENDIX D

INORGANIC ARSENIC RISK ASSESSMENT FOR GLASS MANUFACTURING PLANTS

QUANTITATIVE EXPRESSIONS OF PUBLIC CANCER RISKS FROM EMISSIONS OF INORGANIC ARSENIC FROM GLASS MANUFACTURING PLANTS

D.1 INTRODUCTION

D.1.1 Overview The quantitative expressions of public cancer risks presented in this appendix are based on (1) a dose-response model that numerically relates the degree of exposure to airborne inorganic arsenic to the risk of getting lung cancer, and (2) numerical expressions of public exposure to ambient air concentrations of inorganic arsenic estimated to be caused by emissions from stationary sources. Each of these factors is discussed briefly below and details are provided in the following sections of this appendix.

D.1.2 The Relationship of Exposure to Cancer Risk

The relationship of exposure to the risk of getting lung cancer is derived from epidemiological studies in occupational settings rather than from studies of excess cancer incidence among the public. The epidemiological methods that have successfully revealed associations between occupational exposure and cancer for substances such as asbestos, benzene, vinyl chloride, and ionizing radiation, as well as for inorganic arsenic, are not readily applied to the public sector, with its increased number of confounding variables, much more diverse and mobile exposed population, lack of consolidated medical records, and almost total absence of historical exposure data. Given such uncertainties, EPA considers it improbable that any association, short of very large increases in cancer, can be verified in the general population with any reasonable certainty by an epidemiological study. Furthermore, as noted by the National Academy of Sciences (NAS)[1], "...when there is exposure to a material, we are not starting at an origin of zero cancers. Nor are we starting at an origin of zero carcinogenic agents in our environment. Thus, it is likely that any carcinogenic agent added to the environment will act by a particular mechanism on a particular cell population that is already being acted on by the same mechanism to induce cancers." In discussing experimental dose-response curves, the NAS observed that most information on carcinogenesis is derived from studies of ionizing radiation with experimental animals and with humans which indicate a linear no-threshold dose-response relationship at low doses. They added that although some evidence exists for thresholds in some animal tissues, by and large, thresholds have not been established for most tissues. NAS concluded that establishing such low-dose thresholds "...would require massive, expensive, and impractical experiments ..." and recognized that the U.S. population "...is a large, diverse, and genetically heterogeneous group exposed to a large variety of toxic agents." This fact, coupled with the known genetic variability to carcinogenesis and the predisposition of some individuals to some form of cancer, makes it extremely difficult, if not impossible, to identify a threshold.

For these reasons, EPA has taken the position, shared by other Federal regulatory agencies, that in the absence of sound scientific evidence to the contrary, carcinogens should be considered to pose some cancer risk at any exposure level. This no-threshold presumption is based on the view that as little as one molecule of a carcinogenic substance may be sufficient to transform a normal cell into a cancer cell. Evidence is available from both the human and animal health literature that cancers may arise from a single transformed cell. Mutation research with ionizing radiation in cell cultures indicates that such a transformation can occur as the result of interaction with as little as a single cluster of ion pairs. In reviewing the available data regarding carcinogenicity, EPA found no compelling scientific reason to abandon the no-threshold presumption for inorganic arsenic.

In developing the exposure-risk relationship for inorganic arsenic, EPA has assumed that a linear no-threshold relationship exists at and below the levels of exposure reported in the epidemiological studies of occupational exposure. This means that any exposure to inorganic arsenic is assumed to pose some risk of lung cancer and that the linear relationship between cancer risks and levels of public exposure is the same as that between cancer risks and levels of occupational exposure. EPA believes that this assumption is reasonable for public health protection in light of presently available information. However, it should be recognized that the case for the linear no-threshold dose-response relationship model for inorganic arsenic is not quite as strong as that for carcinogens which interact directly or in metabolic form with DNA. Nevertheless, there is no adequate basis for dismissing the linear no-threshold model for inorganic arsenic. At low concentrations it is the Agency's belief that the exposure-risk relationship used by EPA represents only a plausible upper-limit risk estimate in the sense that the risk is probably not higher than the calculated level and could be much lower.

The numerical constant that defines the exposure-risk relationship used by EPA in its analysis of carcinogens is called the unit risk estimate. The unit risk estimate for an air pollutant is defined as the lifetime cancer risk occurring in a hypothetical population in which all individuals are exposed throughout their lifetimes (about 70 years) to an average concentration of 1 $\mu g/m^3$ of the agent in the air which they breathe. Unit risk estimates are used for two purposes: (1) to compare the carcinogenic potency of several agents with each other, and (2) to give a crude indication of the public health risk which might be associated with estimated air exposure to these agents.

The unit risk estimate for inorganic arsenic that is used in this appendix was prepared by combining the five different exposure-risk numerical constants developed from four occupational studies.[2] The methodology used to develop the unit risk estimate from the four studies is described in D.2 below.

D.1.3 Public Exposure

The unit risk estimate is only one of the factors needed to produce quantitative expressions of public health risks. Another factor needed is a numerical expression of public exposure, i.e., the numbers of people exposed to the various concentrations of inorganic arsenic. The difficulty of defining public exposure was noted by the National Task Force on Environmental Cancer and Health and Lung Disease in their 5th Annual Report to Congress, in 1982.[3] They reported that "...a large proportion of the American population works some distance away from their homes and experience different types of pollution in their homes, on the way to and from work, and in the workplace. Also, the American population is quite mobile, and many people move every few years." They also noted the necessity and difficulty of dealing with long-term exposures because of "...the long latent period required for the development and expression of neoplasia [cancer]..." [The reader should note that the unit risk estimate has been changed from that value used in the inorganic NESHAP proposal as a result of EPA's analysis of several occupational epidemiological studies that have recently been completed.]

EPA's numerical expression of public exposure is based on two estimates. The first is an estimate of the magnitude and location of long-term average ambient air concentrations of inorganic arsenic in the vicinity of emitting sources based on air dispersion modeling using long-term estimates of source emissions and meteorological conditions. The second is an estimate of the number and distribution of people living in the vicinity of emitting sources based on 1980 Bureau of Census data which "locates" people by population centroids in census tract areas. The people and concentrations are combined to produce numerical expressions of public exposure by an approximating technique contained in a computerized model. The methodology is described in D.3 below.

D.1.4 Public Cancer Risks

By combining numerical expressions of public exposure with the unit risk estimate, two types of numerical expressions of public cancer risks are produced. The first, called individual risk, relates to the person or persons estimated to live in the area of highest concentration as estimated by the computer model. Individual risk is expressed as "maximum lifetime risk." As used here, the work "maximum" does not mean the greatest possible risk of cancer to the public. It is based only on the maximum annual average exposure estimated by the procedure used. The second, called aggregate risk, is a summation of all the risks to people estimated to be living within the vicinity (usually within 50 kilometers) of a source and is customarily summed for all the sources in a particular category. The aggregate risk is expressed as incidences of cancer among all of the exposed population after 70 years of exposure; for convenience, it is often divided by 70 and expressed as cancer incidences per year. These calculations are described in more detail in D.4 below.

There are also risks of nonfatal cancer and other potential health effects, depending on which organs receive the exposure. No numerical expressions of such risks have been developed; however, EPA considers all of these risks when making regulatory decisions on limiting emissions of inorganic arsenic.

D.2 THE UNIT RISK ESTIMATE FOR INORGANIC ARSENIC[2]

The following discussion is summarized from a more detailed description of the Agency's derivation of the inorganic arsenic unit risk estimate as found in EPA's "Health Assessment Document for Inorganic Arsenic (EPA-600/8-83-021F).

D.2.1 The Linear No-Threshold Model for Estimation of Unit Risk Based on Human Data (General)

The methodologies used to arrive at quantitative estimates of risk must be capable of being implemented using the data available in existing epidemiologic studies of exposure to airborne arsenic. In order to extrapolate from the exposure levels and temporal exposure patterns in these studies to those for which risk estimates are required, it is assumed that the age-specific mortality rate of respiratory cancer per year per 100,000 persons for a particular 5-year age interval, i, can be represented using the following linear absolute or additive risk model:

$$a_i(D)=a_i + 100{,}000a'D \qquad (1)$$

With this model, a_i is the age-specific mortality rate per year of respiratory cancer in a control population not exposed to arsenic, a' is a parameter representing the potential of airborne arsenic to cause respiratory cancer, and D is some measure of the exposure to arsenic up to the ith age interval. For example, D might be the cumulative dose in years-$\mu g/m^3$, the cumulative dose neglecting exposure during the last 10 years prior to the ith age interval, or the average dose in $\mu g/m^3$ over some time period prior to the ith age interval. The forms to be used for D are constrained by the manner in which dose was treated in each individual epidemiologic study. At low exposures the extra lifetime probability of respiratory cancer mortality will vary correspondingly (e.g., linearly).

The dose-response data available in the epidemiologic studies for estimating the parameters in these models consists primarily of a dose measure D_j for the jth exposure group, the person-years of observation Y_j, the observed number of respiratory cancer deaths O_j, and the number E_j of these deaths expected in a control population with the same sex and age distribution as the exposure group. The expected number E_j is calculated as

$$E_j = \sum_i Y_{ji} a_i / 100{,}000 \qquad (2)$$

where Y_{ji} is the number of person-years of observation in the ith age category and the jth exposure group ($Y_j = \sum_i Y_{ji}$). This is actually a simplified representation, because the calculation also takes account of the change in the age-specific incidence rates with absolute time. The expected number of respiratory cancer deaths for the ith exposure group is

$$\begin{aligned} E(O_j) &= \sum_i Y_{ji} \, (a_i + 100{,}000a'D_j)/100{,}000 \\ &= E_j + a'Y_jD_j \qquad (3) \end{aligned}$$

under the linear absolute risk model. Consequently, $E(O_j)$ can be expressed in terms of quantities typically available from the published epidemiologic studies.

Making the reasonable assumption that O_j has a Poisson distribution, the parameter a' can be estimated from the above equation using the method of maximum likelihood. Once this parameter is estimated, the age-specific mortality rates for respiratory cancer can be estimated for any desired exposure pattern.

To estimate the corresponding additional lifetime probability of respiratory cancer mortality, let $b_1, \ldots, b_{18}$ be the mortality rates, in the absence of exposure, for all cases per year per 100,000 persons for the age intervals 0-4, 5-9,..., 80-84, and 85+, respectively; let $a_1, \ldots, a_{18}$ represent the corresponding rates for malignant neoplasms of the respiratory system. The probability of survival to the beginning of the ith 5-year age interval is estimated as

$$\prod_{j=1}^{i-1} [1 - 5b_j/100{,}000] \qquad (4)$$

Given survival to the beginning of age interval i, the probability of dying of respiratory cancer during this 5-year interval is estimated as

$$5a_i/100{,}000 \qquad (5)$$

The probability of dying of respiratory cancer given survival to age 85 is estimated as a_{18}/b_{18}. Therefore, the probability of dying of respiratory cancer in the absence of exposure to arsenic can be estimated as:

$$P_0 = \sum_{i=1}^{17} [5a_i/100{,}000) \prod_{j=1}^{i-1} (1-5b_j/100{,}000)] \qquad (6)$$

$$+(a_{18}/b_{18}) \prod_{j=1}^{17} (1 - 5b_j/100{,}000)$$

Here the mortality rates a_i apply to the target population for which risk estimates are desired, and consequently will be different from those in (1)-(5), which applied to the epidemiologic study cohort. If the 1976 U.S. mortality rates (male, female, white, and non-white combined) are used in this expression, then $P_0 = 0.0451$.

To estimate the probability P_{EP} of respiratory cancer mortality when exposed to a particular exposure pattern EP, the formula (6) is again used, but a_i and b_i are replaced by $a_i(D_i)$ and $b_i(D_i)$, where D_i is the exposure measure calculated for the ith age interval from the exposure pattern EP. For example, if the dose measure used in (1) is cumulative dose to the beginning of the ith age interval in μg/m^3-years, and the exposure pattern EP is a lifetime exposure to a constant level of 10 μg/m^3, then $D_i = (i-1)(5)(10)$, where the 5 accounts for the fact that each age interval has a width of 5 years. The additional risk of respiratory cancer mortality is estimated as

$$P_{EP} - P_0 \qquad (7)$$

If the exposure pattern EP is constant exposure to 1 μg/m^3, then $P_{EP} - P_0$ is called the "unit risk."

This approach can easily be modified to estimate the extra probability of respiratory cancer mortality by a particular age due to any specified exposure pattern.

D.2.2 Risk Estimates from Epidemiologic Studies

Prospective studies of the relationship between mortality and exposure to airborne arsenic have been conducted for the Anaconda, Montana smelter and the Tacoma, Washington smelter. Table D.1 summarizes the fits of both absolute and relative-risk models, with either $k = 1$ or $k = 2$, to dose-response data from 4 different studies at the two smelters. (See the "Health Assessment Document for Inorganic Arsenic," chapter 7, EPA-600/8-83-021F for detailed description of occupational studies.)

Table D.1 also displays the carcinogenic potencies a'. It should be noted that the potencies estimated from different models are in different units, and are therefore not comparable.

In every case, a linear model ($k = 1$) fitted the data better than the corresponding quadratic model ($k = 2$). In every case but two, the fits of the quadratic model could be rejected at the 0.01 level. The two exceptions involved the two smallest data sets (Higgins et al. absolute risk, and Ott et al.) and in the former case the fit was very marginal ($p = 0.017$). On the other hand, for each data set a linear model provided an adequate fit. Also, in every case, an absolute-risk linear model fit the data better than the corresponding relative-risk linear model. The p-values for the fits of the absolute-risk linear model ranged from 0.025 to 0.75.

The estimated unit risk is presented for each fit for which the chi-square goodness-of-fit p-value is greater than 0.01. The unit risks derived from linear models--8 in all--range from 0.0013 to 0.0136. The largest of these is from the Ott et al. study, which probably is the least reliable for developing quantitative estimates, and which also involved exposures to pentavalent arsenic, whereas the other studies involved trivalent arsenic. The unit risks derived from the linear ($k = 1$) absolute-risk models are considered to be the most reliable; although derived from 5 sets of data involving 4 sets of investigators and 2 distinct exposed populations, these estimates are quite consistent, ranging from 0.0013 to 0.0076.

To establish a single point estimate, the geometric mean for data sets is obtained within distinct exposed populations, and the final estimate is taken to be the geometric mean of those values. This process is illustrated in Table D.2.

TABLE D.1 SUMMARY OF QUANTITATIVE RISK ANALYSES

Exposed Population	Study and Data Source	Model	Results of Goodness-of-Fit Test				
			k	Carcinogenic Potency (a)[a]	x^2 (d.f.)	p-Value	"unit" risk[b]
Anaconda smelter workers	Lee Feldstein (heavy exposure omitted)	absolute risk	1	2.48(-7)	12.7(5)	0.025	2.80(-3)
			2	2.09(-11)	60(5)	0.00001	lack of fit[d]
		relative risk	1	3.00(-4)	28(5)	0.00004	lack of fit
			2	2.09(-8)	79(5)	0.00001	lack of fit
	Higgins et al.	absolute risk	1	2.36(-7)	1.2(3)	0.75	4.90(-3)
			2	1.74(-11)	10.3(3)	0.017	1.05(-4)
		relative risk	1	3.17(-4)	2.57(3)	0.46	4.03(-3)
			2	2.18(-8)	15.4(3)	0.0015	lack of fit
	Brown & Chu	absolute risk	1	9.45(-16)	7.01(7)	0.41	1.25(-3)
ASARCO smelter workers	Enterline & Marsh (zero lag)	absolute risk	1	6.04(-7)[c]	5.5(4)	0.24	6.81(-3)
			2	1.43(-10)	20.7(4)	0.0003	lack of fit
		relative risk	1	4.6(-4)	11.6(4)	0.02	5.44(-3)
			2	1.01(-7)	23.4(4)	0.00011	lack of fit
	Enterline & Marsh (10-year lag)	absolute risk	1	8.85(-7)	7.0(4)	0.14	7.60(-3)
			2	2.01(-10)	26.1(4)	0.00003	lack of fit
		relative risk	1	5.13(-4)	14.5(4)	0.006	lack of fit
			2	1.06(-4)	28.9(4)	0.00002	lack of fit
Dow pesticide manufacture workers	Ott et al. (high exposure omitted)	relative risk	1	9.2(-4)	5.0(7)	0.66	1.36(-2)
			2	1.58(-7)	9.4(7)	0.23	7.68(-4)

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[a] Potencies are in different units, depending upon model used (see text), and consequently are not comparable.
[b] Additional lifetime risk of respiratory cancer mortality from lifetime environmental exposure to 1 $\mu g/m^3$ arsenic.
[c] 6.04(E-7) means 6.04×10^{-7}.
[d] p-value of chi-square goodness-of-fit test is less than 0.01.

TABLE D.2 COMBINED UNIT RISK ESTIMATES FOR ABSOLUTE-RISK LINEAR MODELS

Exposure Source	Study	Unit Risk	Geometric Mean Unit Risk	Final Estimated Unit Risk
Anaconda smelter	Brown & Chu	1.25×10^{-3}		
	Lee-Feldstein	2.80×10^{-3}	2.56×10^{-3}	
	Higgins et al.	4.90×10^{-3}		4.29×10^{-3}
ASARCO smelter	Enterline & Marsh	6.81×10^{-3}		
		7.60×10^{-3}	7.19×10^{-3}	

D.3 QUANTITATIVE EXPRESSIONS OF PUBLIC EXPOSURE TO INORGANIC ARSENIC EMITTED FROM GLASS MANUFACTURING PLANTS

D.3.1 EPA's Human Exposure Model (HEM) (General)

EPA's Human Exposure Model is a general model capable of producing quantitative expressions of public exposure to ambient air concentrations of pollutants emitted from stationary sources. HEM contains (1) an atmospheric dispersion model, with included meteorological data, and (2) a population distribution estimate based on Bureau of Census data. The only input data needed to operate this model are source data, e.g., plant location, height of the emission release point, and temperature of the off-gases. Based on the source data, the model estimates the magnitude and distribution of ambient air concentrations of the pollutant in the vicinity of the source. The model is programmed to estimate these concentrations within a radial distance of 50 kilometers from the source. If the user wishes to use a dispersion model other than the one contained in HEM to estimate ambient air concentrations in the vicinity of a source, HEM can accept the concentrations if they are put into an appropriate format.

Based on the radial distance specified, HEM numerically combines the distributions of pollutant concentrations and people to produce quantitative expressions of public exposure to the pollutant.

D.3.1.1 Pollutant Concentrations Near a Source

The dispersion model within the HEM is a climatological model which uses a sector-averaged gaussian dispersion algorithm. The algorithm has been simplified to improve computational efficiency.[5] The algorithm is evaluated for a representative set of input values as well as actual plant data, and the concentrations input into the exposure algorithm are arrived at by interpolation. Stability array (STAR) summaries are the principal meteorological input to the HEM dispersion model. STAR data are standard climatological frequency-of-occurence summaries formulated for use in EPA models and available for major U.S. meteorological monitoring sites from the National Climatic Center, Asheville, N.C. A STAR summary is a joint frequency-of-occurrence of wind speed, atmospheric stability, and wind direction, classified according to Pasquill's categories. The STAR summaries in HEM usually reflect five years of meteorological data for each of 314 sites nationwide. The model produces polar coordinate receptor grid points consisting of 10 downwind distances located along each of 16 radials which represent wind directions. Concentrations are estimated by the dispersion model for each of the 160 receptors located on this grid. The radials are separated by 22.5-degree intervals beginning with 0.0 degrees and proceeding clockwise to 337.5 degrees. The 10 downwind distances for each radial are 0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 30.0, 40.0, and 50.0 kilometers. The center of the receptor grid for each plant is assumed to be the plant center.

D.3.1.2 Justification for 50 Kilometer Modeling

At proposal, exposure and risk were estimated for people residing within 20 kilometers of the smelter. Some commenters pointed out that since people beyond 20 kilometers are exposed to some level of arsenic due to a source's emissions, EPA's proposal analysis underestimates the total exposure and risk. EPA agrees with this comment and has expanded its analysis out to 50 kilometers. There are several reasons for EPA to extend its analysis out to 50 kilometers. When applying air dispersion models, the EPA's modeling guidelines recommend that, because of the increasing uncertainty of estimates with distance from the modeled source and because of the paucity of validation studies at larger distances, the impact may extend out to 50 kilometers, but the analysis should generally be limited to this distance from the source.[4] Such site-specific factors as terrain features (complex or flat), the objectives of the modeling exercise, and distance to which the model has been validated will determine the appropriate distance (whether greater than or less than the guideline distance) for which the Agency should apply the model.

Unless the technical or other considerations do not allow it, EPA has decided to extend their hazardous air pollutant regulatory analysis for inorganic arsenic out to 50 kilometers. The Administrator believes that the potential to identify additional significant public exposure outweighs the increased inaccuracies of applying the models beyond the previously accepted 20 kilometer radius.

D.3.1.3 Methodology for Reviewing Pollutant Concentrations

Before making HEM computer runs, EPA reviewed U.S. Geological Survey topographical maps (scale 1:24000) to verify locational data for each glass manufacturing plant. Plants were given exact latitude and longitude values which were then incorporated into the HEM program. Such information was critical to the accuracy of the model in utilizing STAR data for each site. The other major inputs for the HEM, emissions data, were also carefully screened to insure accurate model predictions.

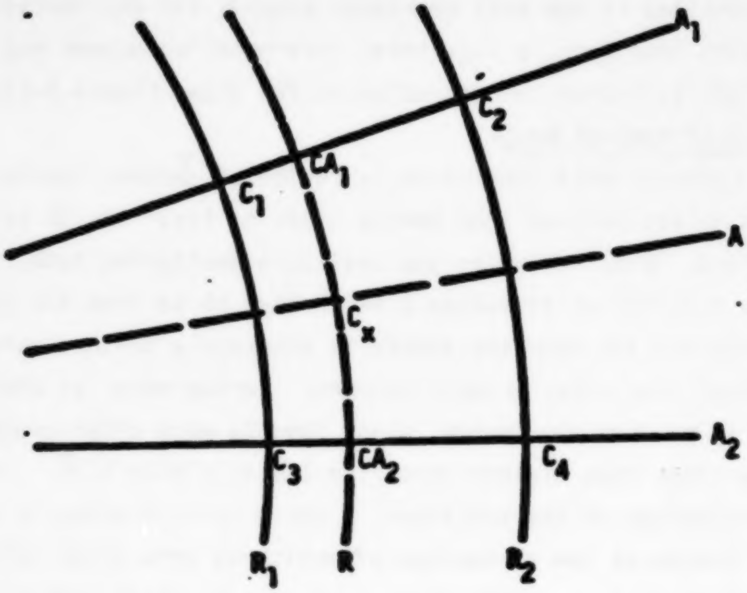
After completing the HEM runs, nearby monitoring sites with ambient air quality data were identified by computer from the National Aerometric Data Bank (NADB) (Table D.3). In some cases, data for several years at individual monitors were included in the NADB retrieval and were expressed as average values with different sample sizes for the years monitored. In these instances, weighted multi-year averages were calculated to provide an overall mean for each monitoring site. For purposes of mean calculations, values measured below minimum detection limits were considered as equal to one half the detection limit. These ambient arsenic data were then compared to HEM predicted values in order to gauge the accuracy of the air dispersion model's estimates. As noted above, HEM predicted values were based on concentrations calculated to occur at 160 polar coordinate receptor grid points consisting of 10 downwind distances located along each of 16 radials which represented wind directions. Because the actual monitoring site locations identified in the NADB retrieval usually did not correspond to exact grid point locations, a log-linear interpolation scheme was used to caluclate an HEM estimated concentration at the site (Figure D-1).

D.3.1.3.1 Use of Ambient Data

Certain criteria were considered in review of ambient levels. Mean concentration values derived from smaple sizes of less than 25 data points were disregarded. When reviewing the available monitoring data, it appeared that monitors situated at distances greater than 15 km from the glass plant were considered too far from the source to accurately measure emissions without interference from other arsenic sources. Furthermore, at distances greater than 15 km from the source, plant impacts were often predicted to be significantly lower than minimum detection limits (Table D.3). These data were not incorporated in the analyses. A third consideration in reviewing ambient data concerned the percentage of monitored data which fell below minimum detection limits. Although some monitoring sites registered data with over 90 percent of the values above minimum detection levels, many had about half the data points below such levels. Instances where more than 50 percent of the data were below MDL were disregarded.

Although fifteen glass manufacturing plants were included in the analyses, review of National Aerometic Data Bank data revealed that only four sites had monitors located within a 15 km radium of the source (Table D.1). Three of these listed only one monitor - Glass Plant Numbers 1, 4 and 14. Because concentration was expressed as a single weighted mean value for each monitoring location, the result was a single data point. This was insufficient information on which to run a regression analysis. The fourth location, Glass Plant Number 6, cited four monitors inside 15 km. However, this plant could not be analyzed due to the fact that between 95 and 99 percent of the monitored concentrations were below analytical detection limits.

Figure D-1 Group 2 BC/ED Interpolation



Given:

A = The angle in radians subtended clockwise about the source from due south to the BC/ED centroid;

A1 = The angle from due south to the radial line immediately counter-clockwise of A, or passing through A if there is an exact match;

A2 = The angle from due south to the radial line immediately clockwise of A1 (A2 is 0 if it is due south);

R = The distance in km from the source to the BC/ED centroid;

R1 = The distance from the source to the largest circular arc of radius less than R;

R2 = The distance from the source to the smallest circular arc of radius greater than or equal to R;

C1 = The natural logarithm of the concentration value at (A1,R1);

C2 = The natural logarithm of the concentration value at (A1,R2);

C3 = The natural logarithm of the concentration value at (A2,R1);

C4 = The natural logarithm of the concentration value at (A2,R2);

then:

RTEMP = ln(R/R1)/ln(R2/R1);

ATEMP = (A-A1)/(A2-A1);

CA1 = exp(C1 + (C2-C1)xRTEMP);

CA2 = exp(C3 + (C4-C3)xRTEMP); and

CX = CA1 + (CA2-CA1)xATEMP,

where CX is the interpolated concentration at the BG/ED centroid.

D.3.1.4 The People Living Near A Source

To estimate the number and distribution of people residing within 50 kilometers of the glass manufacturing plant, the HEM model uses the 1980 Master Area Reference File (MARF) from the U.S. Bureau of Census. This data base consists of enumeration district/block group (ED/BG) values. MARF contains the population centroid coordinates (latitude and longitude) and the 1980 population of each ED/BG (approximately 300,000) in the United States (50 States plus the District of Columbia). HEM identifies the population around each plant, by using the geographical coordinates of the plant, and identifies, selects, and stores for later use those ED/BGs with coordinates falling within 50 kilometers of plant center.

For each of the 15 glass plant locations, a detailed check was made to determine whether the exposed population as predicted by the HEM was located accurately. Based on information obtained from a U.S. Geological Survey map of the area around Glass Plant 15, a revised maximum exposure concentration was used. Plants 1 and 8 were modeled using site-specific terrain and plant parameters (Section D.4.2.1). For these plants, exposure concentrations were taken from the site-specific model predictions. These results are summarized in Table D.4.

D.3.1.5 Exposure[5]

The Human Exposure Model (HEM) uses the estimated ground level concentrations of a pollutant together with population data to calculate public exposure. For each of 160 receptors located around a plant, the concentration of the pollutant and the number of people estimated by the HEM to be exposed to that particular concentration are identified. The HEM multiplies these two numbers to produce exposure estimates and sums these products for each plant.

A two-level scheme has been adopted in order to pair concentrations and populations prior to the computation of exposure. The two-level approach is used because the concentrations are defined on a radius-azimuth (polar) grid pattern with non-uniform spacing. At small radii, the grid cells are usually smaller than ED/BG's; at large radii, the grid cells are usually larger than ED/BG's. The area surrounding the source is divided into two regions, and each ED/BG is classified by the region in which its centroid lies. Population exposure is calculated differently for the ED/BG's within each region. For ED/BG centroids located between 0.2 km and 3.5 km from the emission source, populations are divided between neighboring concentration grid points. There are 64 (4 x 16) polar grid points within this range. Each grid point has a polar sector defined by two concentric arcs and two wind direction radials. Each of these grid points and respective concentrations are assigned to the nearest ED/BG centroid identified from 1980 U.S. Census Bureau data. Each ED/BG can be paired with one or many concentration points. The population associated with the ED/BG centroid is then divided among all concentration grid points assigned to it. The land area within each polar sector is considered in the apportionment.

For population centroids between 3.5 km and 50 km from the source, a concentration grid cell, the area approximating a rectangular shape bounded by four receptors, is much larger than the area of a typical ED/BG. Since there is an approximate linear relationship between the logarithm of concentration and the logarithm of distance for receptors more than 2 km from the source, the entire population of the ED/BG is assumed to be exposed to the concentration that is logarithmically interpolated radially and arithmetically interpolated azimuthally from the four receptors bounding the grid cell. Concentration estimates for 96 (6 x 16) grid cell receptors at 5.0, 10.0, 20.0, 30.0, 40.0 and 50.0 km from the source along each of 16 wind directions are used as reference points for this interpolation.

In summary, two approaches are used to arrive at coincident concentration/population data points. For the 64 concentration points within 3.5 km of the source, the pairing occurs at the polar grid points using an apportionment of ED/BG population by land area. For the remaining portions of the grid, pairing occurs at the ED/BG centroids themselves through the use of log-log and linear interpolation. (For a more detailed discussion of the model used to estimate exposure, see Reference 5.)

D.3.2 Public Exposure to Inorganic Arsenic Emissions from Glass Manufacturing Plants

D.3.2.1 Source Data

Fifteen glass manufacturing plants are included in the analysis. Table D.5 lists the names and addresses of the plants considered, and Table

D.6 lists the plant data used as input to the Human Exposure Model (HEM).

D.3.2.2 Exposure Data

Table D.7 lists, on a plant-by-plant basis, the total number of people encompassed by the exposure analysis and the total exposure. Total exposure is the sum of the products of number of people times the ambient air concentration to which they are exposed, as calculated by HEM. Table D.8 sums, for the entire source category (15 plants), the numbers of people exposed to various ambient concentrations, as calculated by HEM.

Table D.3

Arsenic Concentrations Near Select Glass Manufacturing Plants

Plant	# Obs.	Distance[1]	Bearing	HEM Predicted[2]	ISCLT/ Valley Predicted	NADB Measured	MDL[3]	Percentile[4]
Glass Plant #6	76	.5	73.7	0.00154		0.025	0.05	>99*
	77	.6	246.1	0.00097		0.025	0.05	>99*
	77	.6	43.4	0.0017		0.026	0.05	95< % <99*
	69	.7	23.2	0.0017		0.026	0.05	95< % <99*
Glass Plant #14	41	8.6	168.7	0.000115		0.007	0.0055	50< % <70*
Glass Plant #1	65	3.2	66.1	0.0025	0.0035	0.003	0.0055	90< % <95*
Glass Plant #4	24	1.0	189.6	0.013		0.003	0.0055	>99*
	84	2.1	172.7	0.0062		0.003	0.0055	70< % <90*

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* Indicates data point was disregarded; see Section D.3.1.3.1

[1] Distance from source to monitor (km)

[2] Concentration predicted by Human Exposure Model (HEM) - see Section D.3.1

[3] Minimum Detection Limit

[4] Percentile indicates percentage of data falling below minimum detectable levels

Table D.4

Predicted Maximum Concentrations to Which Individuals are Exposed

Source	Baseline Conc.[1]	Control Conc.[1]	Baseline # of People Exposed	Control # of People Exposed	Baseline Revised[2] Conc.	Control Revised Conc.	Population Location Distance (km) From Source	Population Location Direction
5	4.3×10^{-4}*	4.3×10^{-4}*	1	1			0.2*	E*
6	6.7×10^{-3}*	6.7×10^{-3}*	3	3			0.2*	N*
14	2.6×10^{-3}*	2.6×10^{-3}*	86	86			0.5*	ESE*
13	3.4×10^{-3}*	3.4×10^{-3}*	14	14			0.5*	N*
8	1.97×10^{-1}	1.26×10^{-2}	19	19	3.7×10^{-1}	--	0.25	ESE
12	1.61×10^{-4}*	1.61×10^{-4}*	3	3			0.5*	ESE*
9	9.2×10^{-2}*	4.6×10^{-3}*	88	1,780			0.5*	E*
10	6.1×10^{-4}*	6.1×10^{-4}*	58	58			1.0*	NE*
11	6.3×10^{-3}*	3.2×10^{-3}*	100	100			1.0*	NE*
3	5.5×10^{-3}*	5.5×10^{-3}*	1	1			0.2*	SE*
7	4.9×10^{-3}*	4.9×10^{-3}*	183	183			0.2*	ENE*
1	1.71×10^{-2}	1.29×10^{-3}*	50	752	1.83×10^{-2}	--	1.0	N
2	1.04×10^{-2}*	1.0×10^{-2}*	20	20			0.5*	E*
4	6.0×10^{-2}*	2.1×10^{-3}*	72	393			0.2*	N*
15	8.4×10^{-2}	1.85×10^{-2}	8	78	2.2×10^{-1}	3.9×10^{-2}	0.2	ENE

[1] As indicated by HEM computer model.

[2] Revision to Plant 15 based on review of USGS maps for comparison of HEM predicted population locations versus actual residential sites. Revisions to Plants 1 and 8 based on concentrations predicted by site-specific analyses conducted for those two plants. See Section D.4.2.1.

* Unchanged--HEM results are considered accurate.

TABLE D.5

IDENTIFICATION OF GLASS MANUFACTURING PLANTS

Plant Number Code	Plant Name and Address
1	Owens-Illinois Shreveport, LA
2	Owens-Illinois Mt. Pleasant, PA
3	Owens-Illinois Pittston, PA
4	Owens-Illinois Toledo, OH
5	RCA Circleville, OH
6	GTE Versailles, KY
7	Fostoria Moundsville, WV
8	Corning Martinsburg, WV
9	Corning Charleroi, PA
10	Corning (Fall Brook) Corning, NY
11	Corning (Main Plant) Corning, NY
12	Corning State College, PA
13	North American Phillips Danville, KY
14	GTE Sylvania Central Falls, RI
15	Indiana Glass Dunkirk, IN

Table D.6a Input Data to Exposure Model Glass Manufacturing (Assuming Baseline Controls)

Plant	(Furnace)	Latitude (Degrees Minutes Seconds)	Longitude (Degrees Minutes Seconds)	Emission Rate (Kg/yr)	Emission Point Elevation (Meters)	Emission Point Diameter (Meters)	Emission* Point Cross Sectional Area (m^2)	Emission Point Gas Exit Velocity m/sec	Emission Point Gas Temp. (°K)	Emission Point Type
5	1	393411	0825718	27.6	22.0	1.52	750	14.0	505	Stack
	2			5.9	10.0	0.95	750	9.3	436	Stack
6		380246	0844504	75.0	16.0	1.50	750	4.8	699	Stack
14		415346	0712320	190.5	40.0	0.90	750	8.5	412	Stack
13		374527	0844948	190.0	41.0	1.83	750	4.5	440	Stack
8		392312	0780103	13284.	41.0	2.40	750	3.4	666	Stack
12		405006	0774728	23.4	46.0	1.60	750	14.2	483	Stack
9	1	400835	0795403	1778.0	9.0	0.76	750	23.0	643	Stack
	2			1629.0	8.0	0.76	750	13.6	697	Stack
	3			72.8	31.0	1.20	750	17.4	461	Stack
10		420835	0770242	120.0	26.0	1.20	750	22.9	477	Stack
11	1	420842	0770335	795.0	27.0	1.10	750	14.0	755	Stack
	2			38.1	27.0	0.69	750	15.2	477	Stack
3		411705	0754619	400.0	23.0	1.52	750	12.6	522	Stack
7		395512	0804414	38.5	13.0	0.61	750	8.6	367	Stack
1	1	322806	0934753	747.0	53.0	1.00	750	12.2	530	Stack
	2			795.0	53.0	1.00	750	12.2	544	Stack
	3			858.0	23.0	1.05	750	22.1	569	Stack

*Assumed 750 m^2 for all glass manufacturing plants, this is the vertical cross sectional area of the emission point to the mean wind direction for purpose of calculating downwash.

Table D.6a Input Data to Exposure Model Glass Manufacturing (Concluded)
(Assuming Baseline Controls)

Plant	(Furnace)	Latitude (Degrees Minutes Seconds)	Longitude (Degrees Minutes Seconds)	Emission Rate (Kg/yr)	Emission Point Elevation (Meters)	Emission Point Diameter (Meters)	Emission* Point Cross Sectional Area (m^2)	Emission Point Gas Exit Velocity m/sec	Emission Point Gas Temp. (°K)	Emission Point Type
2		400837	0793201	400.0	13.0	0.61	750	21.0	658	Stack
4	1	414011	0833102	198.7	31.0	1.50	750	2.3	531	Stack
	2			198.7	31.0	1.50	750	2.7	538	Stack
	3			198.7	31.0	1.40	750	2.3	575	Stack
	4			87.4	20.0	0.80	750	14.7	516	Stack
	5			79.5	20.0	0.80	750	15.4	486	Stack
	6			278.1	20.0	0.80	750	21.1	544	Stack
	7			220.5	38.0	1.80	750	4.5	609	Stack
	8			198.7	31.0	1.20	750	2.7	514	Stack
	9			198.7	31.0	1.20	750	5.3	615	Stack
15	1	402233	0851306	1360.0	11.0	1.00	2200	9.1	644	Stack
	2			2260.0	8.0	1.40	2200	9.1	644	Stack
	3			1360.0	38.0	1.00	2200	9.1	644	Stack
	4			950.0	22.0	0.89	2200	9.1	644	Stack
	5			386.0	15.0	0.40	2200	9.1	1644	Stack
	6			895.0	15.0	0.89	2200	9.1	1644	Stack
	7			343.0	15.0	0.40	2200	9.1	1644	Stack
	8			45.0	15.0	0.40	2200	9.1	1533	Stack
	9			45.0	15.0	0.40	2200	9.1	1533	Stack

*Assumed 750 m^2 for all glass manufacturing plants, this is the vertical cross sectional area of the emission point to the mean wind direction for purpose of calculating downwash.

Table D.6b Input Data to Exposure Model Glass Manufacturing
(Assuming BAT Controls)

Plant	(Furnace)	Latitude (Degrees Minutes Seconds)	Longitude (Degrees Minutes Seconds)	Emission Rate (Kg/yr)	Emission Point Elevation (Meters)	Emission Point Diameter (Meters)	Emission* Point Cross Sectional Area (m^2)	Emission Point Gas Exit Velocity m/sec	Emission Point Gas Temp. (°K)	Emission Point Type
1		322806	0934753	360.0	35.0	1.42	750	21.1	477	Stack
2		400837	0793201	400.0	13.0	0.61	750	21.0	658	Stack
3		411705	0754619	400.0	23.0	1.52	750	12.6	522	Stack
4	1	414011	0833102	114.5	35.0	0.83	750	20.0	477	Stack
	6			134.4	35.0	0.83	750	20.4	477	Stack
5	1	393411	0825718	27.6	22.0	1.52	750	14.0	505	Stack
	2			5.9	10.0	0.95	750	9.3	436	Stack
6		380246	0844504	75.0	16.0	1.50	750	4.8	699	Stack
7		395512	0804414	38.5	13.0	0.61	750	8.6	367	Stack
8		392312	0780103	1992.6	41.0	0.76	750	21.1	377	Stack
9	1	400835	0795403	511.1	35.0	0.91	750	18.5	477	Stack
	3			72.8	31.0	1.20	750	17.4	461	Stack
10		420835	0770242	120.0	26.0	1.20	750	22.9	477	Stack
11	1	420842	0770335	119.3	27.0	1.10	750	9.4	477	Stack
	2			38.1	27.0	0.69	750	15.2	477	Stack

Table D.6a Input Data to Exposure Model Glass Manufacturing (Concluded)
(Assuming Baseline Controls)

Plant	(Furnace)	Latitude (Degrees Minutes Seconds)	Longitude (Degrees Minutes Seconds)	Emission Rate (Kg/yr)	Emission Point Elevation (Meters)	Emission Point Diameter (Meters)	Emission* Point Cross Sectional Area (m^2)	Emission Point Gas Exit Velocity m/sec	Emission Point Gas Temp. (°K)	Emission Point Type
12		405006	0774728	23.4	46.0	1.60	750	14.2	483	Stack
13		374527	0844948	190.0	41.0	1.83	750	4.5	440	Stack
14		415346	0712320	190.5	40.0	0.90	750	8.5	412	Stack
15	1	402233	0851306	889.5	35.0	1.12	2200	20.4	477	Stack
	5			386.0	15.0	0.40	2200	9.1	1644	Stack
	6			134.3	35.0	0.51	2200	18.6	477	Stack
	7			343.0	15.0	0.40	2200	9.1	1644	Stack
	8			45.0	15.0	0.40	2200	9.1	1533	Stack
	9			45.0	15.0	0.40	2200	9.1	1533	Stack

TABLE D.7 TOTAL EXPOSURE AND NUMBER OF PEOPLE EXPOSED (GLASS MANUFACTURING PLANTS)*

Plant	Total Number of People Exposed	Total Exposure (People - $\mu g/m^3$)
5	835,000	5
6	434,000	10
14	2,530,000	148
13	428,000	7
8	346,000	1620
12	257,000	1
9	2,080,000	1830
10	270,000	17
11	268,000	82
3	697,000	87
7	372,000	21
1	369,000	690
2	1,450,000	163
4	834,000	1070
15	408,000	627

* A 50-kilometer radius was used for the analysis of glass manufacturing plants.

TABLE D.8

PUBLIC EXPOSURE FOR GLASS MANUFACTURING PLANTS AS PRODUCED BY THE HUMAN EXPOSURE MODEL

Concentration Level ($\mu g/m^3$)	Population Exposed (Persons)*	Exposure (Persons - $\mu g/m^3$)**
0.216	0	0
0.1	486	64
0.05	4740	346
0.025	20800	907
0.01	79800	1830
0.005	189000	2580
0.0025	523000	3740
0.001	1210000	4820
0.0005	2380000	5610
0.00025	3900000	6180
0.0001	5100000	6370
0.00005	6770000	6500
0.000025	7570000	6530
0.00001	9580000	6560
0.000005	10800000	6570
0.0000025	11400000	6570
0.000001	11500000	6570
0.000000593	11600000	6570

*Column 2 displays the computed value, rounded to the nearest whole number, of the cumulative number of people exposed to the matching and higher concentration levels found in column 1. For example, 0.5 people would be rounded to 0 and 0.51 people would be rounded to 1.

**Column 3 displays the computed value of the cumulative exposure to the matching and higher concentation levels found in column 1.

D.4 QUANTITATIVE EXPRESSIONS OF PUBLIC CANCER RISKS FROM INORGANIC ARSENIC EMITTED FROM GLASS MANUFACTURING PLANTS

D.4.1 Methodology (General)

D.4.1.1 The Two Basic Types of Risk

Two basic types of risk are dealt with in the analysis. "Aggregate risk" applies to all of the people encompassed by the particular analysis. Aggregate risk can be related to a single source, to all of the sources in a source category, or to all of the source categories analyzed. Aggregate risk is expressed as incidences of cancer among all of the people included in the analysis, after 70 years of exposure. For statistical convenience, it is often divided by 70 and expressed as cancer incidences per year. "Individual risk" applies to the person or persons estimated to live in the area of the highest ambient air concentrations and it applies to the single source associated with this estimate as estimated by the dispersion model. Individual risk is expressed as "maximum lifetime risk" and reflects the probability of getting cancer if one were continuously exposed to the estimated maximum ambient air concentration for 70 years.

D.4.1.2 The Calculation of Aggregate Risk

Aggregate risk is calculated by multiplying the total exposure produced by HEM (for a single source, a category of sources, or all categories of sources) by the unit risk estimate. The product is cancer incidences among the included population after 70 years of exposure. The total exposure, as calculated by HEM, is illustrated by the following equation:

$$\text{Total Exposure} = \sum_{i=1}^{N} (P_i C_i)$$

where

$\sum$ = summation over all grid points where exposure is calculated

P_i = population associated with grid point i,

C_i = long-term average inorganic arsenic concentration at grid point i,

N = number of grid points to 2.8 kilometers and number of ED/BG centroids between 2.8 and 50 kilometers of each source.

To more clearly represent the concept of calculating aggregate risk, a simplified example illustrating the concept follows:

EXAMPLE

This example uses assumptions rather than actual data and uses only three levels of exposure rather than the large number produced by HEM. The assumed unit risk estimate is 3×10^{-3} at 1 $\mu g/m^3$ and the assumed exposures are:

ambient air concentrations	number of people exposed to given concentration
2 $\mu g/m^3$	1,000
1 $\mu g/m^3$	10,000
0.5 $\mu g/m^3$	100,000

The probability of getting cancer if continuously exposed to the assumed concentrations for 70 years is given by:

concentration		unit risk		probability of cancer
2 $\mu g/m^3$	x	$3 \times 10^{-3} (\mu g/m^3)^{-1}$	=	6×10^{-3}
1 $\mu g/m^3$	x	3×10^{-3} "	=	3×10^{-3}
0.5 $\mu g/m^3$	x	3×10^{-3} "	=	1.5×10^{-3}

The 70 year cancer incidence among the people exposed to these concentrations is given by:

probability of cancer at each exposure level		number of people at each exposure level		cancer incidences after 70 years of exposure
6×10^{-3}	x	1,000	=	6
3×10^{-3}	x	10,000	=	30
1.5×10^{-3}	x	100,000	=	150
			TOTAL =	186

The aggregate risk, or total cancer incidence, is 186 and, expressed as cancer incidence per year, is 186 ÷ 70, or 2.7 cancers per year. The total cancer incidence and cancers per year apply to the total of 111,000 people assumed to be exposed to the given concentrations.

D.4.1.3 The Calculation of Individual Risk

Individual risk, expressed as "maximum lifetime risk," is calculated by multiplying the highest concentration to which the public is exposed, as reported by HEM, by the unit risk estimate. The product, a probability of getting cancer, applies to the number of people which HEM reports as being exposed to the highest listed concentration. The concept involved is a simple proportioning from the 1 $\mu g/m^3$ on which the unit risk estimate is based to the highest listed concentration. In other words:

$$\frac{\text{maximum lifetime risk}}{\text{highest concentration to which people are exposed}} = \frac{\text{the unit risk estimate}}{1\ \mu g/m^3}$$

D.4.2 Risks Calculated for Emissions of Inorganic Arsenic from Glass Manufacturing Plants

The explained methodologies for calculating maximum lifetime risk and cancer incidences were applied to each glass manufacturing plant assuming a baseline level of emissions. A baseline level of emissions means the level of emissions after the application of controls either currently in place or required to be in place to comply with current state or Federal regulations but before application of controls that would be required by a NESHAP.

Table D.9 summarizes the calculated risks. To understand the relevance of these numbers, one should refer to the analytical uncertainties discussed in section D.5 below.

D.4.2.1 Site-Specific Analysis

In its original risk assessment, EPA did not consider terrain effects or the full effect of building downwash on stack emissions from glass manufacturing plants. These plants oftentimes have short stacks whose effluents can be entrained in the building wake on the leeward side of the furnace buildings or other adjacent structures. As a consequence, it was regarded as likely that airborne arsenic concentrations to which persons might be exposed near or adjacent to these plants could be underestimated. In addition, it was felt that the extent of building downwash could be expected to be different depending on the degree of control applied. If so, the relative reduction in risk achieved by any particular control option might differ from that estimated previously.

For these reasons, additional dispersion analyses were carried out to examine these concerns further. These analyses were done for two glass plant locations, Martinsburg, Virginia and Shreveport, Louisiana. For the Shreveport analysis, the Industrial Source Complex Long Term (ISCLT) model was used in conjunction with a joint frequency distribution of wind speed, stability class, and wind direction derived from surface weather observations at Greater Shreveport Municipal Airport. In order to better assess the impact of building downwash on the rise of the hot furnace gases, a modified plume rise treatment similar to that in the Buoyant Line and Point Source (BLP) model was used in addition to the standard ISCLT plume rise treatment. Both the building downwash and standard ISCLT analyses included an enhancement to the dispersion of the plume as appropriate, an enhancement which is a part of the ISCLT model. The two sets of analyses were intended to bracket the expected effects of building downwash on airborne inorganic arsenic concentrations.

Results obtained from HEM and the two site-specific analyses for Shreveport can be seen in Tables D.10 - D.12. Table D.10 outlines arsenic concentrations estimated by the Human Exposure Model (HEM) to occur at 16 wind directions and eight distances downwind from the Shreveport plant center. Table D.11 shows corresponding values based on the standard ISCLT model run in conjunction with a joint frequency distribution of wind speed, stability class and wind direction. Table D.12 shows values based on the ISCLT model used in conjunction with modified plume rise treatment. Agreement between the HEM and ISCLT estimates is fairly good with differences rarely exceeding a factor of 1 or 2. The HEM tends to underpredict slightly in regions of higher and lower concentration.

For the Martinsburg analysis, the same approach was taken, except that the effects of terrain were also considered. Martinsburg is located on a broad plateau at the foot of a long ridge. ISCLT was used to estimate airborne inorganic arsenic concentrations at any receptor located at or below the top of the furnace stack. However, for receptors above the top of the furnace stack, the Valley model was used. The Valley model allows the plume to intersect terrain features under stable conditions, resulting in high concentrations. For receptors well above the plume centerline, the impact of the plume is gradually reduced. Both models were used in conjunction with a joint frequency distribution of wind speed, stability class, and wind direction derived from surface weather observations at Martinsburg Airport. The modified plume rise treatment described for Shreveport was also included as part of the Martinsburg analysis in addition to the standard treatment of plume rise in ISCLT and Valley. This again resulted in two sets of dispersion analyses, which, as before, were intended to bracket the expected effects of building downwash.

Results obtained from HEM and the two site-specific analyses for Martinsburg can be seen in Tables D.13 - D.15. Table D.13 outlines arsenic concentrations estimated by the HEM to occur at 128 points (see above) around the Martinburg plant. Table D.14 shows corresponding values based on the standard ISCLT and Valley models run in conjunction with a joint frequency distribution of wind speed, stability class, and wind direction. Table D.15 shows values based on the ISCLT/Valley models with modified plume rise treatment. Agreement between the HEM and ISCLT runs is fairly good with differences rarely exceeding a factor of 2. The HEM tends to overpredict slightly at regions of higher concentration with more varied results at regions of lower concentration.

TABLE D.9 MAXIMUM LIFETIME RISK AND CANCER INCIDENCE FOR GLASS MANUFACTURING PLANTS

Plant	Maximum Lifetime Risk		Cancer Incidences Per Year	
	Baseline	Control	Baseline	Control
Owens-Illinois Shreveport, LA	7×10^{-5} 8×10^{-5}*	6×10^{-6} --	0.035 0.042*	0.0037 --
Owens-Illinois Mt. Pleasant, PA	4×10^{-5}	4×10^{-5}	0.010	0.010
Owens-Illinois Pittston, PA	2×10^{-5}	2×10^{-5}	0.0053	0.0053
Owens-Illinois Toledo, OH	3×10^{-4}	9×10^{-6}	0.066	0.0066
RCA Circleville, OH	1.8×10^{-6}	1.8×10^{-6}	0.0003	0.0003
GTE Versailles, KY	3×10^{-5}	3×10^{-5}	0.0006	0.0006
Fostoria Moundsville, WV	2×10^{-5}	2×10^{-5}	0.0013	0.0013
Corning Martinsberg, WV	8×10^{-4} 1.6×10^{-3}*	5×10^{-5} --	0.12 0.099*	0.013 --
Corning Charleroi, PA	4×10^{-4}	2×10^{-5}	0.11	0.012
Corning - Fall Brook Corning, NY	3×10^{-6}	3×10^{-6}	0.0006	0.0006
Corning - Main Corning, NY	3×10^{-5}	1.4×10^{-5}	0.0050	0.0016
Corning State College, PA	7×10^{-7}	7×10^{-7}	0.0001	0.0001
N. Amer. Philips Danville, KY	1.4×10^{-5}	1.4×10^{-5}	0.0011	0.0011
GTE Sylvania Central Falls, RI	1.1×10^{-5}	1.1×10^{-5}	0.0091	0.0091
Indiana Glass Dunkirk, IN	9×10^{-4}	1.7×10^{-4}	0.038	0.0085

* Represents risk estimates calculated from site-specific analyses using ISCLT model.

Table D.10

Estimated Arsenic Concentrations in the Vicinity of A Glass Manufacturing Plant in Shreveport, LA, Based on Human Exposure Model (HEM) Calculations

WIND DIRECTION	DOWNWIND DISTANCE (KM)							
	.500	1.000	2.000	10.000	20.000	30.000	40.000	50.000
S	5.6324-003	8.4473-003	6.8406-003	1.2532-003	4.8404-004	2.7118-004	1.7865-004	1.2891-004
SSW	2.2000-003	3.7360-003	3.0811-003	5.4210-004	2.0765-004	1.1600-004	7.6307-005	5.5013-005
SW	2.5785-003	3.5684-003	2.6739-003	4.5330-004	1.7313-004	9.6598-005	6.3497-005	4.5753-005
WSW	2.4075-003	3.6468-003	2.9414-003	5.2483-004	2.0165-004	1.1275-004	7.4202-005	5.3507-005
W	4.0910-003	6.0476-003	5.1270-003	9.8184-004	3.8088-004	2.1367-004	1.4085-004	1.0167-004
WNW	4.3336-003	6.7628-003	6.2382-003	1.3582-003	5.3661-004	3.0290-004	2.0030-004	1.4486-004
NW	5.2337-003	9.2364-003	9.2797-003	2.1336-003	8.4805-004	4.7971-004	3.1757-004	2.2982-004
NNW	5.1540-003	8.5635-003	7.7797-003	1.6122-003	6.3333-004	3.5690-004	2.3582-004	1.7048-004
N	1.1022-002	1.7106-002	1.4336-002	2.7529-003	1.0714-003	6.0188-004	3.9707-004	2.8677-004
NNE	4.0643-003	5.8914-003	4.8272-003	9.4559-004	3.6944-004	2.0778-004	1.3715-004	9.9083-005
NE	4.3671-003	5.3616-003	4.0195-003	7.8918-004	3.0977-004	1.7448-004	1.1525-004	8.3291-005
ENE	3.7195-003	4.6091-003	3.6239-003	8.0401-004	3.2128-004	1.8205-004	1.2061-004	8.7323-005
E	3.4966-003	4.6576-003	3.9938-003	9.1477-004	3.6578-004	2.0732-004	1.3738-004	9.9472-005
ESE	2.9647-003	4.5868-003	3.9225-003	7.9763-004	3.1323-004	1.7649-004	1.1661-004	8.4288-005
SE	4.1431-003	5.8953-003	4.2665-003	7.0773-004	2.7070-004	1.5119-004	9.9445-005	7.1689-005
SSE	3.0777-003	4.3032-003	3.1535-003	5.2625-004	2.0108-004	1.1226-004	7.3825-005	5.3213-005

Table D.11

Estimated Arsenic Concentrations in the Vicinity of a Glass Manufacturing Plant in Shreveport, LA, Based on Standard Industrial Source Complex Long Term (ISCLT) Model Calculations

DIR	DISTANCE							
	.500	1.000	2.000	10.000	20.000	30.000	40.000	50.000
S	3.5615-003	5.3202-003	5.1253-003	1.2689-003	5.0450-004	2.8582-004	1.9338-004	1.4364-004
SSW	2.3855-003	2.8588-003	2.5026-003	5.5634-004	2.1771-004	1.2257-004	8.2485-005	6.0915-005
SW	2.4981-003	2.7247-003	2.1925-003	4.6670-004	1.8404-004	1.0425-004	7.0500-005	5.2266-005
WSW	2.5827-003	2.8766-003	2.4156-003	5.3922-004	2.1293-004	1.2037-004	8.1239-005	6.0219-005
W	3.6058-003	4.4309-003	4.0042-003	9.9397-004	3.9701-004	2.2545-004	1.5275-004	1.1341-004
WNW	4.1577-003	5.1404-003	4.6549-003	1.3753-003	5.5957-004	3.1948-004	2.1733-004	1.6232-004
NW	4.3674-003	6.3453-003	6.5841-003	2.1629-003	8.8386-004	5.0410-004	3.4242-004	2.5554-004
NNW	4.6422-003	5.6395-003	6.5386-003	1.7013-003	6.7361-004	3.7979-004	2.5622-004	1.9018-004
N	4.8792-003	1.0445-002	1.1117-002	2.8539-003	1.1295-003	6.3770-004	4.3096-004	3.2040-004
NNE	6.4052-003	6.5674-003	5.1180-003	1.0429-003	4.0273-004	2.2608-004	1.5265-004	1.1361-004
NE	2.6264-003	4.4457-003	3.5339-003	8.3120-004	3.3208-004	1.8898-004	1.2865-004	9.6291-005
ENE	1.9770-003	3.8930-003	3.0707-003	8.3904-004	3.4276-004	1.9657-004	1.3456-004	1.0117-004
E	1.9603-003	3.6255-003	3.2719-003	9.5297-004	3.8886-004	2.2227-004	1.5162-004	1.1386-004
ESE	2.9642-003	3.6977-003	3.3384-003	8.3597-004	3.3272-004	1.8832-004	1.2756-004	9.5092-005
SE	2.6873-003	3.8951-003	3.4961-003	7.3775-004	2.8712-004	1.6155-004	1.0896-004	8.0803-005
SSE	4.4306-003	4.4693-003	3.2576-003	5.6012-004	2.1915-004	1.2192-004	8.1645-005	6.0173-005

Table D.12

Estimated Arsenic Concentrations in the Vicinity of a Glass Manufacturing Plant in Shreveport, LA, Based on Building Downwash Industrial Source Complex Long Term Model Calculations

DIR	DISTANCE							
	.500	1.000	2.000	10.000	20.000	30.000	40.000	50.000
S	7.2365-003	8.2159-003	6.3525-003	1.3743-003	5.2472-004	2.9280-004	1.9648-004	1.4516-004
SSW	4.4603-003	4.2216-003	3.2012-003	5.9327-004	2.2469-004	1.2498-004	8.3569-005	6.1455-005
SW	4.2743-003	3.8703-003	2.7901-003	4.9966-004	1.9031-004	1.0641-004	7.1469-005	5.2760-005
WSW	4.6250-003	4.2422-003	3.1337-003	5.7814-004	2.2031-004	1.2291-004	8.2376-005	6.0779-005
W	6.3914-003	6.5952-003	5.3140-003	1.0741-003	4.1236-004	2.3075-004	1.5512-004	1.1457-004
WNW	7.9229-003	8.3340-003	7.3895-003	1.5277-003	5.8895-004	3.2959-004	2.2179-004	1.6447-004
NW	9.5432-003	1.1254-002	1.0656-002	2.4231-003	9.3372-004	5.2119-004	3.4995-004	2.5916-004
NNW	1.2629-002	1.2097-002	9.8726-003	1.8853-003	7.0769-004	3.9136-004	2.6130-004	1.9263-004
N	1.4375-002	1.8335-002	1.5131-002	3.1438-003	1.1836-003	6.5612-004	4.3907-004	3.2431-004
NNE	1.6368-002	1.1154-002	7.4393-003	1.1566-003	4.2347-004	2.3308-004	1.5571-004	1.1507-004
NE	6.1404-003	6.9716-003	5.2036-003	9.3396-004	3.5124-004	1.9549-004	1.3150-004	9.7651-005
ENE	5.2392-003	6.2974-003	4.9771-003	9.6791-004	3.6697-004	2.0479-004	1.3814-004	1.0267-004
E	6.2610-003	6.3365-003	5.3106-003	1.0928-003	4.1533-004	2.3129-004	1.5556-004	1.1575-004
ESE	7.6727-003	5.2275-003	4.8549-003	9.2972-004	3.5046-004	1.9438-004	1.3022-004	9.6366-005
SE	5.8062-003	5.8790-003	4.5470-003	7.9647-004	2.9821-004	1.6535-004	1.1064-004	8.1672-005
SSE	9.1531-003	6.8164-003	4.2475-003	6.2137-004	2.2660-004	1.2444-004	8.2763-005	6.0726-005

Table D.13

Estimated Arsenic Concentrations in the
Vicinity of a Glass Manufacturing Plant in
Martinsburg, West VA, Based on Human
Exposure Model Calculations

WIND DIRECTION	DOWNWIND DISTANCE (KM) .500	1.000	2.000	10.000	20.000	30.000	40.000	50.000
S	1.8336-001	1.6423-001	9.6131-002	1.5250-002	6.6668-003	4.1439-003	2.9723-003	2.3039-003
SSW	1.2574-001	9.9645-002	5.4642-002	8.4341-003	3.5890-003	2.1844-003	1.5416-003	1.1796-003
SW	8.8745-002	7.5102-002	4.3030-002	7.0833-003	3.0687-003	1.8840-003	1.3371-003	1.0274-003
WSW	4.2470-002	3.2595-002	1.7738-002	2.7987-003	1.1824-003	7.1225-004	4.9810-004	3.7819-004
W	6.2595-002	5.1067-002	2.8863-002	4.7611-003	2.0471-003	1.2476-003	8.8010-004	6.7286-004
WNW	6.3859-002	5.2153-002	2.9345-002	4.6003-003	1.9704-003	1.2038-003	8.5187-004	6.5319-004
NW	1.3456-001	1.1694-001	6.7732-002	1.0877-002	4.7278-003	2.9193-003	2.0825-003	1.6069-003
NNW	1.0655-001	8.7287-002	4.9121-002	7.3793-003	3.1768-003	1.9595-003	1.3985-003	1.0801-003
N	1.7633-001	1.6732-001	1.0100-001	1.5937-002	7.0379-003	4.4166-003	3.1920-003	2.4892-003
NNE	1.5266-001	1.5516-001	9.4408-002	1.5037-002	6.7016-003	4.2345-003	3.0760-003	2.4081-003
NE	1.8166-001	1.9716-001	1.2480-001	2.0241-002	9.1027-003	5.7847-003	4.2189-003	3.3129-003
ENE	1.1913-001	1.1277-001	6.7118-002	1.0417-002	4.6064-003	2.8989-003	2.1002-003	1.6411-003
E	1.8602-001	1.6294-001	9.3900-002	1.3979-002	6.0765-003	3.7864-003	2.7248-003	2.1185-003
ESE	1.6363-001	1.4894-001	8.1731-002	1.1399-002	4.8318-003	2.9688-003	2.1163-003	1.6339-003
SE	1.6497-001	1.5977-001	9.1574-002	1.3663-002	5.9163-003	3.6736-003	2.6362-003	2.0452-003
SSE	1.2657-001	1.0219-001	5.6375-002	8.1492-003	3.4813-003	2.1430-003	1.5284-003	1.1802-003

Table D.14

Estimated Arsenic Concentrations in the Vicinity of a Glass Manufacturing Plant in Martinsburg, West VA, Based on Standard Industrial Source Complex Long Term (ISCLT) and Valley Model Calculations

DIR	DISTANCE							
	.500	1.000	2.000	10.000	20.000	30.000	40.000	50.000
S	4.4084-002	4.2807-002	3.8995-002	1.0710-002	5.3440-003	3.2133-003	2.1350-003	2.6503-003
SSW	2.9573-002	3.0094-002	2.2791-002	7.1150-003	3.5626-003	2.7276-003	1.9701-003	9.7558-004
SW	1.6067-002	1.6316-002	1.6115-002	7.4371-003	3.7583-003	2.1350-003	1.5362-003	9.0761-004
WSW	9.2087-003	1.2228-002	8.9281-003	3.9404-003	1.4492-003	1.0695-003	6.8812-004	5.6315-004
W	1.7280-002	1.5518-002	1.4333-002	3.8373-003	2.7167-003	1.3685-003	1.0443-003	8.4640-004
WNW	1.3905-002	1.9275-002	2.3155-002	3.9718-003	2.8081-003	9.4244-004	1.1685-003	9.0019-004
NW	2.6030-002	4.1030-002	4.1573-002	7.4834-003	3.8144-003	3.3591-003	1.8691-003	1.5171-003
NNW	3.0733-002	4.7666-002	2.7771-002	9.4417-003	3.9370-003	1.6988-003	1.2106-003	1.4165-003
N	3.4179-002	4.7460-002	3.5914-002	1.4099-002	4.9835-003	5.0595-003	3.8218-003	2.6274-003
NNE	2.9638-002	3.2578-002	2.7095-002	9.8353-003	4.7658-003	2.9701-003	2.1020-003	1.9520-003
NE	3.2362-002	3.4669-002	2.9453-002	1.1452-002	5.6231-003	3.5241-003	2.6283-003	2.6876-003
ENE	3.6437-002	3.2734-002	2.4072-002	7.5497-003	3.5859-003	2.4120-003	1.9178-003	1.6001-003
E	7.1946-002	5.7090-002	3.5562-002	9.8125-003	4.4663-003	2.7211-003	1.9042-003	1.4464-003
ESE	5.8013-002	6.7269-002	4.2032-002	8.9196-003	3.8976-003	2.8471-003	1.6197-003	1.7223-003
SE	6.9531-002	5.6610-002	4.0676-002	9.2608-003	4.1728-003	3.0799-003	1.5921-003	1.3336-003
SSE	4.9025-002	4.1219-002	2.7550-002	6.7957-003	3.1954-003	1.8434-003	1.3123-003	9.7017-004

Table D.15

Estimated Arsenic Concentrations in the Vicinity of a Glass Manufacturing Plant in Martinsburg, West VA, Based on Building Downwash Standard Industrial Source Complex Long Term (ISCLT) and Valley Model Calculations

DIR	DISTANCE							
	.500	1.000	2.000	10.000	20.000	30.000	40.000	50.000
S	1.3673-001	9.4666-002	6.9567-002	1.3220-002	5.9310-003	3.4699-003	2.2933-003	2.5270-003
SSW	9.0262-002	6.3092-002	3.5919-002	8.5029-003	3.9668-003	2.9923-003	2.0343-003	1.0283-003
SW	5.0714-002	3.9281-002	2.5217-002	8.7643-003	4.1310-003	2.1356-003	1.5605-003	8.5014-004
WSW	2.7278-002	2.4345-002	1.4616-002	4.8143-003	1.5897-003	1.1521-003	7.2974-004	5.6159-004
W	3.6783-002	3.2295-002	2.4297-002	4.5863-003	2.8245-003	1.3776-003	1.0367-003	8.4321-004
WNW	4.3702-002	4.0172-002	3.5983-002	4.7848-003	2.8371-003	9.2814-004	1.1989-003	8.8615-004
NW	8.2408-002	8.7600-002	6.5687-002	9.0623-003	3.9854-003	3.4549-003	1.8760-003	1.4575-003
NNW	8.9851-002	9.5119-002	4.6416-002	1.1040-002	4.3691-003	1.8469-003	1.2896-003	1.4391-003
N	1.1267-001	1.0681-001	6.7228-002	1.6477-002	5.6721-003	5.6238-003	3.9736-003	2.4631-003
NNE	1.0115-001	7.6754-002	5.2240-002	1.2529-002	5.4698-003	3.2906-003	2.2840-003	2.0921-003
NE	1.1192-001	8.4935-002	5.6916-002	1.4725-002	6.4831-003	3.9180-003	2.8313-003	2.3189-003
ENE	1.0763-001	7.1276-002	4.3659-002	9.5127-003	4.0955-003	2.6065-003	1.9545-003	1.4702-003
E	1.9395-001	1.1649-001	6.4915-002	1.2047-002	5.0358-003	2.9775-003	2.0494-003	1.5430-003
ESE	2.2962-001	1.2966-001	6.5772-002	1.0711-002	4.3435-003	3.0521-003	1.7320-003	1.2960-003
SE	1.9159-001	1.1456-001	6.7486-002	1.1317-002	4.6837-003	3.0690-003	1.5242-003	1.4193-003
SSE	1.3712-001	8.3267-002	4.5805-002	8.2518-003	3.5365-003	2.0048-003	1.3963-003	1.0300-003

D.5 ANALYTICAL UNCERTAINTIES APPLICABLE TO THE CALCULATIONS OF PUBLIC HEALTH RISKS CONTAINED IN THIS APPENDIX

D.5.1 The Unit Risk Estimate

The procedure used to develop the unit risk estimate is described in reference 2. The model used and its application to epidemiological data have been the subjects of substantial comment by health scientists. The uncertainties are too complex to be summarized sensibly in this appendix. Readers who wish to go beyond the information presented in the reference should see the following Federal Register notices: (1) OSHA's "Supplemental Statement of Reasons for the Final Rule", 48 FR 1864 (January 14, 1983); and (2) EPA's "Water Quality Documents Availability" 45 FR 79318 (November 28, 1980).

The unit risk estimate used in this analysis applies only to lung cancer. Other health effects are possible; these include skin cancer, hyperkeratosis, peripheral neuropathy, growth retardation and brain dysfunction among children, and increase in adverse birth outcomes. No numerical expressions of risks relevant to these health effects is included in this analysis.

Although the estimates derived from the various studies are quite consistent, there are a number of uncertainties associated with them. The estimates were made from occupational studies that involved exposures only after employment age was reached. In estimating risks from environmental exposures throughout life, it was assumed, through either the relative-risk model (1) or the absolute-risk model (2), that the increase in the age-specific mortality rates of lung cancer was a function only of cumulative exposures, irrespective of how the exposure was accumulated. Although this assumption provides an adequate description of all of the data, it may be in error when applied to exposures that begin very early in life. Similarly, the linear models possibly are inaccurate at low exposures, even though they provide excellent descriptions of the experimental data.

The risk assessment methods employed were severly constrained by the fact that they were based only upon the analyses performed and reported by the original authors--analyses that had been performed for purposes other than quantitative risk assessment. For example, although other measures of exposure might be more appropriate, the analyses were necessarily based upon cumulative dose, since that was the only usable measure reported. Given greater access to the data from these studies, other dose measures, as well as models other than the simple relative-risk and absolute-risk models, could be studied. It is possible that such wide analyses would indicate that other approaches are more appropriate than the ones applied here.

D.5.2 Public Exposure

D.5.2.1 General

The basic assumptions implicit in the methodology are that all exposure occurs at people's residences, that people stay at the same location for 70 years, that the ambient air concentrations and the emissions which cause these concentrations persist for 70 years, and that the concentrations are the same inside and outside the residences. From this it can be seen that public exposure is based on a hypothetical premise. It is not known whether this results in an over-estimation or an underestimation of public exposure.

D.5.2.2 The Public

The following are relevant to the public as dealt with in this analysis:

1. Studies show that all people are not equally susceptible to cancer. There is no numerical recognition of the "most susceptible" subset of the population exposed.

2. Studies indicate that whether or not exposure to a particular carcinogen results in cancer may be affected by the person's exposure to other substances. The public's exposure to other substances is not numerically considered.

3. Some members of the public included in this analysis are likely to be exposed to inorganic arsenic in the air in the workplace, and workplace air concentrations of a pollutant are customarily much higher than the concentrations found in the ambient, or public air. Workplace exposures are not numerically approximated.

4. Studies show that there is normally a long latent period between exposure and the onset of lung cancer. This has not been numerically recognized.

5. The people dealt with in the analysis are not located by actual residences. As explained previously, people are grouped by census districts and these groups are located at single points called the population centroids. The effect is that the actual locations of residences with respect to the estimated ambient air concentrations are not known and that the relative locations used in the exposure model may have changed since the 1980 census. However, for the population sectors estimated to be at highest risk, U.S. Geological Survey topographical maps were checked to verify that people did live or could live in locations near the sources as modeled predictions estimated. Maps in certain instances were old and the possibility could not be excluded that additional areas near sources have been developed since publication of the maps.

6. Many people dealt with in this analysis are subject to exposure to ambient air concentrations of inorganic arsenic where they travel and shop (as in downtown areas and suburban shopping centers), where they congregate (as in public parks, sports stadiums, and schoolyards), and where they work outside (as mailmen, milkmen, and construction workers). These types of exposures are not numerically dealt with.

3.5.2.3. The Ambient Air Concentrations

The following are relevant to the estimated ambient air concentrations of inorganic arsenic used in this analysis:

1. Flat terrain was assumed in the dispersion model. Concentrations much higher than those estimated would result if emissions impact on elevated terrain or tall buildings near a plant.

2. The estimated concentrations do not account for the additive impact of emissions from plants located close to one another.

3. The increase in concentrations that could result from re-entrainment of arsenic-bearing dust from, e.g., city streets, dirt roads, and vacant lots, is not considered.

4. Meteorological data specific to plant sites are not used in the dispersion model. As explained, HEM uses the meteorological data from the STAR station nearest the plant site. Site-specific meteorological data could result in significantly different estimates, e.g., the estimates of where the higher concentrations occur.

5. In some cases, the arsenic emission rates are based on assumptions rather than on emission tests.

D.6 References

1. National Academy of Sciences, "Arsenic," Committee on Medical and Biological Effects of Environmental Pollutants, Washington, D.C., 1977. Docket Number (OAQPS 79-8) II-A-3.

2. Health Assessment Document for Inorganic Arsenic - Final Report EPA-600/8-83-021F March 1984, OAQPS Docket Number OAQPS 79-8, II-A-13.

3. U.S. EPA, et.al., "Environmental Cancer and Heart and Lung Disease," Fifth Annual Report to Congress by the Task Force on Environmental Cancer and Health and Lung Disease, August, 1982.

4. OAQPS Guideline Series, "Guidelines on Air Quality Models." Publication Number EPA-450/2-78-027 (OAQPS Guideline No. 1.2-080).

5. Systems Application, Inc., "Human Exposure to Atmospheric Concentrations of Selected Chemicals." (Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, North Carolina). Volume I, Publication Number EPA-2/250-1, and Volume II, Publication Number EPA-1/250-2.